Food and Agriculture Organization of the United Nations

Integrated Fire Management Voluntary Guidelines

Principles and strategic actions

Second edition

FORESTRY WORKING PAPER
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ISSN 2664-1062

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2024

Required citation:
FAO. 2024. *Integrated Fire Management Voluntary Guidelines – Principles and strategic actions.* Second edition. Forestry Working Paper, No. 41. Rome. https://doi.org/10.4060/cd1090en

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ISSN 2664-1062 [print]
ISSN 2664-1070 [online]

ISBN 978-92-5-138916-4
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First edition 2006

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Niger. A farmer burning straw to fertilize the earth for the next planting season
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Foreword

Damaging wildfires in many parts of the world in recent years have prompted an increase in demand for technical support for integrated fire management. As part of the response, FAO and the United Nations Environment Programme (UNEP) established the Global Fire Management Hub (Fire Hub), which was launched by FAO Director-General Qu Dongyu, at the eighth International Wildland Fire Conference in May 2023. The aim of the Fire Hub is to strengthen the capacity of countries to implement integrated fire management and reduce the negative effects of wildfires on people, landscapes and the global climate. One of the Fire Hub's first activities was to update FAO's *Fire Management: Voluntary Guidelines. Principles and strategic actions*, which was published in 2006, to guide implementation of integrated fire management at the landscape level, enhance best fire management practices, including cultural practices for sustainable land use, and engage diverse stakeholders.

This second edition of the guidelines, now titled, *Integrated Fire Management Voluntary Guidelines – Principles and strategic actions*, benefited from contributions from the Global Fire Monitoring Center (GFMC), the International Liaison Committee of the International Wildland Fire Conferences, and Regional Fire Management Resource Centers in the GFMC's Global Wildland Fire Network. In addition, FAO engaged with experts in countries and specialized partner institutions for insights into new developments and solutions in integrated fire management.

This document was presented to the Twenty-Seventh Session of the Committee on Forestry in July 2024 for consideration as a living, open document that will be updated regularly, thereby building on the latest knowledge, policies and experiences in the implementation of integrated fire management globally.

Zhimin Wu
Director, FAO Forestry Division

Acknowledgements

The first edition of *Fire Management: Voluntary Guidelines. Principles and strategic actions*[a] was prepared after a two-year multistakeholder process involving governments, non-governmental and intergovernmental organizations, and private-sector fire specialists and practitioners from around the world, including the following: United States Forest Service; Global Fire Monitoring Center (GFMC), Germany; Australasian Fire Authorities Council, Australia; Corporación Nacional Forestal, Chile; Jonkershoek Forestry Research Centre, CSIR Natural Resources and the Environment, Council for Scientific and Industrial Research, South Africa; Servicio Nacional contra Incendios Forestales, Dirección General de Conservación de la Naturaleza, Ministerio de Medio Ambiente, Spain; the Global Fire Initiative, The Nature Conservancy; National Rural Fire Office, New Zealand; Institut national de recherche pour l'agriculture, l'alimentation et l'environnement, Unité de recherches forestières méditerranéennes, France; and the Training Institute in Ecology and Nature Management, the Russian Federation. Valuable feedback was also received from the six Regional Forestry Commissions, FAO Members, and a wide range of organizations involved in various aspects of fire management.

This second edition, *Integrated Fire Management Voluntary Guidelines – Principles and strategic actions*, updates the original guidelines. Lara Steil, FAO Forestry Officer (Fire Management), served as lead author, with a core team at FAO comprising Livia Carvalho Moura, Peter Moore and William de Groot, as well as Johann Goldammer of the GFMC. The following FAO staff also provided inputs: Amy Duchelle, Brett Shields, Tiina Vähänen and Petteri Vuorinen (FAO Forestry); Phuong Le Ha and The Chien Nguyen (FAO Viet Nam); and Anne Brunel, Charlotte Milbank, Nahideh Naghizadeh and Maria Paola Rizzo (FAO Indigenous Peoples Unit). Alastair Sarre provided a technical edit.

The second edition benefited from valuable inputs from the following fire specialists: Gary Morgan, Murray Dudfield and Neil Cooper, Australian/New Zealand Forest Fire Management Group, Australia and New Zealand; Carmen Taylor, Chelene Hanes and Karima Bakka, Canadian Forest Service, Canada; Bambang Hero Saharjo, Regional Fire Management Resource Center Southeast Asia, Indonesia; Nikola Nikolov, Regional Fire Monitoring Center, North Macedonia; Eunsang Cho and Chansong Kim, Korea Forest Service,

[a] FAO. 2006. *Fire Management: Voluntary Guidelines. Principles and strategic actions.* Fire Management Working Paper 17. Rome. https://www.fao.org/4/j9255e/j9255e00.htm

Republic of Korea; Tiago Oliveira, Mario Monteiro and João Carlos Verde, Agência para a Gestão Integrada de Fogos Rurais, Portugal; Maria Sokolenko, Federal Forestry Agency and Andrey Eritsov, Aerial Forest Fire Center, the Russian Federation; Francesco Gaetani, United Nations Environment Programme; Gordon Sachs, United States Forest Service and International Liaison Committee; Cara Sponaugle and Dave Calleryand, United States Forest Service National Burned Area Emergency Response; and Scott Dehnisch, United States Agency for International Development, Bureau for Humanitarian Assistance, United States of America.

This working paper is the first knowledge product produced in the context of the Fire Hub, which has been supported by the Governments of Canada, France, Germany, Portugal, the Republic of Korea and the United States of America.

The collective effort of this product emphasizes FAO's collaborative approach to cultivating a robust and cooperative international community on integrated fire management. FAO extends its sincere thanks to the contributors to both editions for their dedication and time.

Abbreviations

AIIMS	Australasian Inter-service Incident Management System
CBFiM	community-based fire management
FAO	Food and Agriculture Organization of the United Nations
FDRS	fire danger rating system
GFMC	Global Fire Monitoring Center
IATF	UNISDR Inter-Agency Task Force for Disaster Reduction
ICS	Incident Command System
IFM	integrated fire management
IPCC	Intergovernmental Panel on Climate Change
IWFC	International Wildland Fire Conference
NDC	nationally determined contribution
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNISDR	United Nations International Strategy for Disaster Reduction (now UNDRR)
WG-4	Working Group on Wildland Fire
WHO	World Health Organization
WMO	World Meteorological Organization

1. Introduction

The first edition of *Fire Management: Voluntary Guidelines. Principles and strategic actions*[1] sets out a framework of legally non-binding principles and internationally accepted strategic actions that addressed multiple dimensions of fire management at all levels.

Since 2006, FAO has adopted the more holistic integrated fire management (IFM) approach that is centred on five key elements: (1) review and analysis; (2) risk reduction; (3) readiness; (4) response; and (5) recovery. Integrated fire management integrates economic, sociocultural and environmental aspects crucial for fire management.[2] It draws on good practices around the world by stakeholders at all levels, including Indigenous Peoples and local community experience and expertise.[3,4] Fire science has also evolved since 2006, particularly with respect to the many influences of climate change.[5]

This second edition of the guidelines reflects the IFM concept, including through its revised title (hereafter, "IFM Voluntary Guidelines"). It refines principles 3 ("traditional uses of fire") and 4 ("protecting lives and assets") to reflect issues of equity and inclusion, particularly related to Indigenous Peoples and other local knowledge holders. Principle 8 in the first edition has been split into two principles in the current edition, "Legislation" and "Policy". The second edition also provides updated terminology and references throughout.

Chapter 1 of the IFM Voluntary Guidelines presents the international context, potential users and implementation guidance for IFM. Chapter 2 addresses cross-sectoral issues. Chapter 3 lays out 12 principles to aid the formulation of IFM policies, laws and regulations. Chapter 4 puts forward strategic actions to promote IFM, and Chapter 5 provides a list of publications and other information resources.

1.1. BACKGROUND

A fire in the present context is any fire, natural or anthropogenic, that burns living or dead vegetation outside the urban or structural environment. Distinctively, a wildfire is any uncontrolled fire that was ignited naturally, intentionally or accidentally that burns vegetation biomass (fuel) and causes adverse economic, social or environmental impacts.

The IFM Voluntary Guidelines use the term landscape fires, which encompasses wildfires, cultural and ecological land-use fires, and planned

and prescribed management fires[b] burning in the vegetation of natural, cultural and urban or industrial landscapes. The scope includes underground, surface and crown fires in natural forests, planted forests, protected natural areas, rangelands, savannahs, grasslands, shrubs, brush, peatlands, swamps, mires, fens and other vegetation types. Landscape fires also encompass fires in managed landscapes, whether planned and monitored or not.

A fire may burn across ecosystem boundaries and various types of lands. The techniques, policies and processes outlined here are applicable to landscape fires as well as fires in settlements and in areas with scattered dwellings and other structures.

Fire management is the discipline of preventing, detecting, controlling and suppressing wildfires, as well as using fire to achieve land management goals. It also involves objectives related to safeguarding life, human health, traditional and Indigenous cultures, livelihoods, property and resources in landscapes and in rural areas. Fire management may include both planned and naturally occurring fires, as well as research and technology sharing.

Integrated fire management is an approach for integrating fire management and the ecological and socioeconomic roles of fire. Important considerations include the use of natural and human-caused fire in maintaining social (e.g. community-, culture- and livelihood-related) and ecological (e.g. ecosystem maintenance and integrity) values, in addition to recognizing the impacts of natural and human-caused fires on vulnerable populations (e.g. due to smoke and to post-wildfire hazards such as increased soil erosion and runoff). Integrated fire management recognizes that fire may be used to reduce the accumulation of natural fuels and residues from commercial and non-commercial activities and in the rehabilitation of ecosystems damaged by or dependent on fire.

The IFM Voluntary Guidelines are applicable to the planning, organization and management of safe, effective and efficient fire management organizations and agencies. They address the three main components of IFM: (1) fire management (prevention, suppression and fire use); (2) fire ecology (key ecological attributes of fire); and (3) fire culture (socioeconomic necessities and impacts). The guidelines also cover the full range of fire management planning activities, including prevention, early warning, detection, mobilization, the suppression of damaging wildfires, and the mitigation of post-wildfire hazards.

1.2. RATIONALE

Many regions of the world have experienced increasing trends in landscape fires in land-use systems, often associated with land-use change, leading to more severe wildfires.[6,7] Some of the effects of wildfires are transboundary: for example, smoke and fire-related water pollution can cross political borders, with associated impacts on human health and safety, biodiversity and land degradation and the potential to cause soil erosion, flooding and desertification.

[b] Prescribed fire is deliberately used fire that has a formal or documented "prescription". Planned fire includes fires that may not have a formal or documented "prescription" but are deliberate. Both terms are used in this document.

The depletion of terrestrial carbon by wildfires burning in extreme conditions in some vegetation types, including organic soils in peatland biomes, is a driving agent in the disturbance of global biogeochemical cycles, notably the global carbon cycle.[8] These and other economic, social, environmental and cultural impacts of landscape fires are confirmed by scientific evidence.[9]

In many fire-dependent ecosystems, the fire regime – that is, the typical pattern of natural or anthropogenic fire frequency, intensity, seasonality, size, type (e.g. subsurface, surface or crown) and severity of recurring fires – determines which species benefit from fire and which decline or are displaced or removed from an ecosystem. Changes to fire regimes, such as the shortening or lengthening of fire frequency, affect vegetation and modify fauna habitats and thus can have severe impacts on biodiversity. The invasion of ecosystems by non-native plants can also lead to substantial changes in fire regimes, often with negative results.

Human population growth is associated with increasing rates of conversion of natural vegetation to agricultural and pastoral systems. Land-use change is occurring in traditionally uninhabited and uncultivated areas, including on steep mountain slopes and in coastal areas and floodplains, as well as in rural areas. Fire is often still used to clear land to produce crops for global markets and is thus implicated in deforestation and land-use change. In many regions, this process is also associated with an increased occurrence of wildfires. In more developed areas, on the other hand, fire intensities increase due to increasing fuel loads when land is abandoned or left unmanaged, potentially increasing damage to resources, property, infrastructure and human health.

Some fire-prone ecosystems have experienced increases in disastrous wildfires after decades of fire-exclusion policies, in which fire was considered harmful to the environment in any conditions. For example, the exclusion of traditional regular fire use in fire-adapted grasslands, savannahs and forests may have resulted in the buildup of fuel hazards and increased the risk of damaging wildfires.

Although some countries still focus on fire exclusion and suppression policies and programmes, others are piloting or have already built new IFM approaches focused on review and analysis, prevention, risk reduction and readiness. Such approaches are based on the participation of stakeholders and focus on prevention to reduce the occurrence of large wildfires in the face of climate change.

Integrated fire management approaches recognize the importance of bridging scientific and traditional knowledge, including the knowledge of Indigenous Peoples and other local communities. The aim is to put in place more inclusive, effective and equitable fire management regimes, including through community-based fire management (CBFiM).[c]

[c] Local knowledge holders might include persons or communities that do not self-identify as Indigenous or are not legally recognized as such but who hold crucial knowledge, in this case regarding fire and sustainable land management.

1.3. OBJECTIVES

The IFM Voluntary Guidelines are intended to serve the following objectives:

- establish principles for responsible IFM, taking into account all relevant economic, social and environmental aspects;
- advocate for sustainable land and resource management programmes that consider the ecologically appropriate use and management of fire, where permitted, and the suppression of unwanted, damaging wildfires;
- encourage and publicize the contributions of effective CBFiM to food security and people's livelihood needs, taking into account (under climate change) the concept of "appropriate" use;
- contribute to the establishment and implementation of national and subnational policies and planning mechanisms for establishing or improving the legal, regulatory and institutional framework required for responsible fire management;
- provide guidance that may be used, where appropriate, in the formulation and implementation of international instruments; and
- facilitate and promote mutual assistance and technical, financial or other forms of cooperation on IFM between agencies and donor organizations.

Special consideration is given herein to social and community values and to engaging local people in fire management planning and implementation.

Any effective IFM programme must consider the ecology and fire history of an area. In many cases, the maintenance of appropriate fire regimes or the reintroduction of fire is as important as preventing unwanted, damaging wildfires. The use and benefits of planned fire are not simply in protection and suppression – it can also have significant biodiversity conservation benefits.

The IFM Voluntary Guidelines provide guidance on the implementation of activities at the interface between people and forests – and other natural ecosystems – with the recognition that ecological values must be considered alongside human values and cultural norms.

1.4. RELATIONSHIP TO OTHER INTERNATIONAL INSTRUMENTS

The IFM Voluntary Guidelines are intended to be interpreted and applied in alignment with existing international instruments, conventions and agreements, particularly the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification, the Convention on Biological Diversity and the 2030 Agenda for Sustainable Development. Their application would constitute steps towards achieving most of the Sustainable Development Goals. Appendix 1 provides a list of selected conventions, agreements and declarations relevant to IFM.

Drawing on other mechanisms as well as technical documents and guidelines (see further reading section), the IFM Voluntary Guidelines encompass the experiences of organizations and individuals globally.

The IFM Voluntary Guidelines do not prejudice the rights, jurisdictions or duties of individual countries under international law, as reflected in international conventions and agreements. They are designed to support and complement the fire management guidelines, policies, programmes and regulations currently in effect in many countries.

1.5. IMPLEMENTATION OF THE PRINCIPLES AND STRATEGIC ACTIONS

Entities with fire management responsibilities may benefit from collaboration when incorporating the IFM Voluntary Guidelines into their policy, legal and regulatory frameworks; IFM strategies, programmes and plans; and standards and guidelines for implementation, monitoring and reporting. Such entities may include FAO Members, as well as non-member countries; relevant subnational, national, regional and global governmental and non-governmental organizations; and all stakeholders concerned with the management of forests, rangelands, savannahs, grasslands and other ecosystems, including protected areas, and the interface between any of these and areas of human development.

Governments, international bodies and non-governmental organizations are encouraged to promote understanding of the IFM Voluntary Guidelines among people and institutions involved in natural resource management, forest conservation, air and water quality, humanitarian assistance, community protection, and restoration and rehabilitation, including, where practicable, through the introduction of processes that promote voluntary acceptance and effective application of the guidelines. Although the IFM Voluntary Guidelines are non-binding, governments are encouraged to review and consider them in their policy, legal and institutional frameworks and in their planning and implementation standards for IFM.

1.6. DIVERSITY OF CONTEXTS AND SPECIAL REQUIREMENTS

The diversity of fire management contexts suggests that there will be wide variation in the approaches taken to applying the principles and implementing the strategic actions set out in this working paper. Organizational capabilities vary between countries and regions with respect to the funding and resources available for active fire management programmes. Environments and fire regimes also vary, from areas with few fires and little fire impact, to areas in which fire is a key component of ecosystem health, to areas where fires cause considerable damage to ecosystem functioning and human health.

The context in which fire management programmes operate is important. Fire management institutions and programmes may be lacking in certain landscapes where fire occurs. Where they exist, fire management programmes may need to be updated to make them safer, more effective, and more environmentally and socially acceptable. Some fire-prone areas are becoming increasingly populated,

complicating fire management. In other areas, people are abandoning rural areas and leaving large tracts of unmanaged lands, which are increasingly at risk of wildfire.

In some areas, fire plays important roles in the environment, such as in sustaining ecosystems and supporting livelihoods through agriculture and other uses. The need to adopt IFM regimes in such areas will grow as populations increase. The need to protect lives, resources and property from the adverse effects of fire must be balanced against the appropriate use of, and need for, fire in the environment.

The capacity of countries to implement the IFM Voluntary Guidelines will vary and should be taken into account. To support implementation, governments, international agencies, non-governmental organizations, financial institutions, landowners and users should recognize the special circumstances and requirements of each country. Emphasis may be needed on financial and technical assistance, technology transfer, training and scientific cooperation to enhance the capacity of countries to strengthen and develop their fire management organizations and capabilities. This may be particularly so for least developed countries, Small Island Developing States and low forest-cover countries in fragile ecosystems where damaging wildfires occur.

2. Cross-sectoral issues

This section addresses cross-sectoral issues that are fundamental to IFM.

2.1. LIVELIHOODS AND POVERTY

Fire can be a natural part of ecosystems and, in some landscapes, used as a tool, it can help ensure a healthy, sustainable supply of food and resources. Therefore, landscape fire is often a beneficial force in improving people's lives and a key component of agricultural practice. In some areas, fire is managed by rural communities and Indigenous Peoples to maintain healthy forests, rangelands, savannahs and grasslands that provide habitats for hunting and the gathering of fruits, nuts, grains and other food sources. Fire may be the most efficient method for improving forage for domestic and wild animals and increasing livestock production, and planned fires can help reduce fuel loads, thus reducing the risk of wildfire. On the other hand, wildfire can damage and destroy homes, food and natural resources, pollute the air, and affect water quality and quantity in catchments. Reducing fuel loads and vegetation cover may help ensure adequate flows of good-quality water.

A comprehensive IFM programme can contribute positively to poverty alleviation, food security, livelihoods, clean water, good health and education. Protection from unwanted, damaging wildfires and the management of fire to benefit society can contribute to these goals.

2.2. SUSTAINABLE ECOSYSTEMS AND ENVIRONMENTAL IMPACTS

Ecological and socioeconomic issues

Maintaining sustainable, properly functioning ecosystems should be a goal of all IFM programmes. In many ecosystems worldwide, vegetation has evolved with fire over millennia, and fire may be needed to maintain healthy structure and function. Fire regimes, therefore, can have considerable influence on landscape vegetation, wildlife and biodiversity.[10] For example, natural variability in fire frequency, intensity, type (e.g. belowground, surface or crown), severity, pattern (e.g. size and shape), and season of burn creates a mosaic of variable fire impacts across a landscape. This pyro-diversity is an important driver of floral biodiversity, and it also promotes faunal biodiversity through both direct fire impacts and its influence on habitat variability.[11]

Ecosystems have evolved under local fire regimes. If those regimes are significantly and rapidly altered, such as by climate change or direct human intervention, it can have a profound impact on local vegetation.[12] For example,

some fire-dependent, healthy, sustainable ecosystems experience infrequent fast-moving, high-intensity wildfires that are ecologically beneficial. If the time interval between fire events shortens, some plant species may be unable to produce viable seed crops and will ultimately become locally extinct, with potentially substantial damage to the ecosystem.

The fire regime needed to maintain ecosystem health varies between ecosystems and landscapes. A fire-sensitive or fire-intolerant ecosystem may need complete protection from human-caused fires. Fire-dependent ecosystems, on the other hand, require fire, which can occur either through a natural fire cycle or the use of planned management fires. Successful IFM to ensure ecosystem sustainability requires an understanding of local fire regimes and fire ecology.

People are closely tied to ecosystems and the environment.[13] This is perhaps most true for rural communities and Indigenous Peoples, who rely on the land and its resources for food and income. Maintaining sustainable ecosystems is essential for them because the consequences of poor IFM implementation, such as the failure to maintain proper fire regimes, may lead to food insecurity, poverty and poor health outcomes. In the long term, this could encourage rural out-migration and potentially lead to the loss of culture and traditions. The dependence of such communities on healthy natural environments for their livelihoods requires the maintenance of sustainable fire management practices.

Maintaining ecologically appropriate fire regimes in landscapes is an important aspect of IFM.[12,14] It requires many decisions, such as when, where, how often, and under what conditions fire is required, and when it is not allowed; it may involve prescribed burning and the planned use of wildfire. Other issues of concern in any fire regime may include (among others) community protection measures, invasive species, species at risk, public health (smoke), and possible post-fire recovery and restoration actions.[15] Local knowledge and the involvement of all stakeholders in IFM decision-making is crucial.

Integrated fire management requires a landscape approach to planning, managing and restoring ecosystems, beyond a focus on small-scale site impacts. A broad view balances impacts and losses, both economic and non-economic. Such losses may be difficult to quantify, but they should be recognized and considered at an appropriate scale. It is also essential to consider the impacts of fire from the perspectives of all stakeholders involved, including a gender perspective because wildfires may have gender-differentiated impacts.[16]

Carbon and climate change

The Intergovernmental Panel on Climate Change (IPCC) concluded in its Sixth Assessment Cycle that the global average surface temperature has increased by 1.1 °C above pre-industrial levels.[17] The consequences of climate change include a rise in lower-atmosphere temperatures; changes in the length and period

of seasons; changes in precipitation patterns that can lead to more severe droughts, more extreme rainfall events, and decreased snow cover and sea ice extent; a rise in sea levels and atmospheric greenhouse-gas concentrations; and more frequent extreme fire weather conditions.

Numerous general circulation models project a global mean temperature increase of 2.4–2.6 °C by 2100 – a change much more rapid than any other experienced in the past 10 000 years. The frequency and severity of extreme weather and climate events are also projected to increase, which will lead to an alteration of fire regimes.[6] Most importantly, more frequent droughts will result in a higher frequency of high-severity wildfires, with potential consequences such as increased vegetation-cover loss, desertification and reduced terrestrial carbon sequestration. Climate change is also increasing the frequency of extreme rainfall events; when these follow soon after wildfire, they exacerbate soil erosion and the potential for landslides.

The Paris Agreement, adopted at the UNFCCC's twenty-first Conference of the Parties in 2015, is a legally binding international treaty with the goal of holding "the increase in the global average temperature to well below 2 °C above pre-industrial levels" and pursuing efforts "to limit the temperature increase to 1.5 °C above pre-industrial levels". Since 2020, countries have been submitting nationally determined contributions (NDCs) that communicate planned actions to reduce greenhouse-gas emissions, build resilience and adapt to the impacts of climate change.

Integrated fire management is essential for maintaining a healthy terrestrial carbon sequestration sink, which is central to all IPCC scenarios to keep global warming below 1.5 °C. All fires in all ecosystems, including wildfires and fires used for sustainable land and resource management, affect carbon pools and the global carbon cycle. At the same time, climate change affects the duration and severity of dry seasons, thus influencing wildfire incidence and severity. The IFM Voluntary Guidelines support national and international capacities for appropriate, proactive fire management responses as they relate to climate change mitigation and adaptation.

2.3. IMPACTS ON HUMAN HEALTH AND SAFETY

Smoke pollution from vegetation fire is an important public health issue, with serious risks for human and environmental health. Wildfires continue to generate major smoke events. The WHO/WMO Health Guidelines on Vegetation Fire Events[18] noted that air pollution from vegetation fires may lead to increased mortality and hospital admissions due to respiratory and cardiovascular diseases. The smoke and haze from planned and unplanned fires can also adversely affect aviation, shipping and vehicular traffic, resulting in risks to safety and the potential to cause significant economic losses.

Some elements of vegetation cover provide an environmental protective

function and confer landscape stability, including above- and belowground plant parts such as stems, leaves and roots; herbaceous plant layers; and the accumulated decomposing plant matter on forest floors. Sites affected by uncharacteristic, high-severity or excessively frequent fires can cause the degradation and loss of these protective elements, leading to (among other things) excessive water runoff and erosion; wind erosion; processes that result in mudslides and rockslides; and flooding at the landscape scale.

Human security can be increased based on the concept of "fire-adapted" communities. The term is well established in describing communities of flora and fauna and can also be applied to human communities to describe an ideal set of conditions in which people live in harmony with the normal occurrence of fires and their impacts. In many parts of the world, however, people living in communities with high incidences of wildfires often lack the necessary institutions and infrastructure to provide adequate protection from wildfires.

2.4. FIRE AS A TOOL IN SUSTAINABLE LAND USE AND RESOURCE MANAGEMENT

The concept of "good" or "benign" fire should be supported and promoted. Fire can be good for habitats, managing land, reducing threats and maintaining cultural values, particularly in the context of agriculture, forestry and other land uses. Fire has been part of agricultural and forest practices by societies for millennia and is still used today. From a fire management perspective, there is generally no difference in the use of fire for planted crops and for promoting the growth of naturally occurring sources of food for consumption by people and livestock. The same is true for the use of fire to maintain traditional or cultural landscapes and vegetation patterns.

2.5. SAFETY CONSIDERATIONS FOR FIREFIGHTERS AND CIVILIANS

For firefighters, fire managers and the public, safety is a core value that cannot be compromised. It is a crucial part of all activities, from planning through to restoration. Indeed, a common reason for establishing a fire management organization is to protect firefighters and communities from wildfires. Even in countries with well-established and highly financed fire management organizations, wildfires can cause devastating levels of human injury and loss of life.

Wildfire events may result in the loss of homes, businesses, schools and critical public infrastructure for power and energy supply, telecommunications and transportation. Protecting communities and saving lives starts with community education and preparation, which includes constructing infrastructure and buildings that facilitate subsequent protective actions. Appropriately designed and constructed buildings offer protection to people during wildfires and reduce the likelihood of fire-related injuries and fatalities. Large wildfires

will burn from the landscape towards built assets, so there should be adequate separation between vegetation and structures. Fuel management in the landscape and around high-value areas can reduce the fire hazard and overall risk.

The safety of firefighters must be given the highest priority in the policies, procedures, plans and management philosophy of any fire management agency or organization. Firefighter safety begins with the provision of proper safety equipment and training for each individual working in fire suppression and prescribed-burning operations. It is highly recommended that, at a minimum, landscape-fire suppression training, both for professionals and volunteers, include the provision of personal protective equipment.

Volunteer and community-based fire brigades are common in many areas prone to severe wildfires, yet these firefighters rarely receive adequate recognition for their efforts and exposure to risk. Such fire brigades and firefighters should be included in IFM programmes to ensure they receive appropriate equipment and training.

Safety training includes education on local weather conditions and terrain and the flammability of fuels. Firefighters must also be trained to recognize important characteristics of fire behaviour, such as fire intensities and spread rates and when a smouldering fire might re-ignite and spread. Crews need to understand how to monitor wildfires and to estimate the potential for changes in fire behaviour to avoid becoming trapped by unanticipated shifts in fire spread rate or direction and by rapid changes in fire intensity.

Public safety is closely tied to IFM. Fires burning in terrain contaminated by landfill waste, industrial pollution, chemical and other hazardous residues or radioactive contamination may cause dangerous emissions that affect human health and safety. Fires burning in terrain contaminated with unexploded ordnance and land mines also pose a serious safety issue.

2.6. LEGAL, POLICY, INSTITUTIONAL AND FINANCIAL FRAMEWORKS

The legal framework of policies, laws and jurisdictional authority is the underlying basis of any IFM programme. In general, the directive that establishes the purpose or objectives for an area (e.g. forest production, cultural landscape conservation or development) will be primary, with IFM directives secondary to this. The agency or landowner responsible for carrying out the primary directive should develop and implement an IFM programme that takes into account the role of fire, the need for protection, and the potential impacts of wildfire on adjacent areas, communities and individuals.

Policies are needed to explain how laws will be interpreted and to what degree. By clearly stating and implementing policies, agencies and land managers will be better positioned to explain the need for IFM, including planned fire, and to maintain the support of the community. If the policy is

unclear, it will be difficult to implement and maintain a programme.

In forested and rural areas where fire is an important tool for land and resource management and a crucial ecosystem feature, a legislative mandate is needed to enable the ongoing use of fire as a management tool. The legal framework should provide accountability for IFM and guarantee that land managers use fire responsibly. It should also ensure that agencies responsible for (for example) conservation, meteorology, land management and fire management work cooperatively together and ensure a proper balance between objectives.

In the context of IFM, an institutional framework can be defined as all the processes and procedures in place to enable the implementation of an IFM programme. An effective and efficient programme can be said to be institutionalized when the framework is ingrained in the thoughts, actions and goals of all those involved in designing and implementing the programme.

An adequate and continuing source of funding is needed to implement an IFM programme. Many activities will take place before a fire starts, yet emergency funding during a wildfire often surpasses the funds invested beforehand to properly train and equip organizations for quick, safe and effective responses. Funding an effective IFM programme that abates the extent and severity of wildfire is likely to be much lower than the cost of reacting to wildfires and those associated with the loss of buildings, structures, resources and livelihoods.

2.7. SCIENCE AND TECHNOLOGY

Fire science is multidisciplinary: it includes numerous classical disciplines, ranging from social and economic sciences to ecology, physics and chemistry. Cultural and anthropological fire history and geography, humanities and the arts address the role of people in shaping the global environment through fire. Interdisciplinary research aims to better understand complex processes such as those involving humans, culture, fire and climate. Continued research and integration across disciplines is crucial if IFM is to advance with new knowledge, tools and technologies.

The transfer of scientific knowledge to fire management and natural resource staff through vocational education is vital for the understanding and practice of IFM, noting that some fire management services are separate from natural resource agencies and enhanced coordination is often needed. Public education is also essential for aspects of wildfire prevention and ecologically sound and safe burning techniques.

The transfer of knowledge from the research community to the public can be accomplished through awareness programmes and citizen engagement. Knowledge exchange should involve understanding the ecological and environmental effects of fire from different perspectives (e.g. through participatory and inclusive methodologies), the design of fire-adapted communities, and how to collect scientific data in standardized ways and to

respond during emergencies.

One of the first steps in knowledge exchange with Indigenous Peoples and other local knowledge holders is to acknowledge their unique wisdom, traditions and perceptions. If knowledge exchange is to be successful, information must be available in languages generally understood by the communities involved. Relevant scientific literature may need to be translated into local languages and adapted to local economic, social and environmental situations. In turn, local languages and understandings may also need to be translated into languages accessible to academics, managers and politicians so they are informed of the knowledge held by Indigenous Peoples and other local knowledge holders.

Local communities may be involved in the collection of data from local networks (e.g. sensor networks), thereby encouraging inclusivity, decentralization and community engagement. Such involvement also empowers volunteers and enhances collective knowledge, benefiting the broader community.

2.8. KNOWLEDGE MANAGEMENT

Most fire-related organizations have systems for storing information and historical documents, but few have comprehensive programmes for knowledge management. A holistic fire knowledge management system goes beyond the minimum requirements for maintaining legal and financial information to include gathering, understanding and using Indigenous and local knowledge in conjunction with scientific and research results. Such a system can guide the appropriate use of the latest technological methods connected to traditional knowledge.

In many fire-dependent or -adapted ecosystems, Indigenous Peoples and other local knowledge holders hold a wealth of information on fire management.[19] Traditional lore and knowledge have been passed down through many generations and may reflect adaptation to environmental conditions over many hundreds of years.[20] Knowledge shared among diverse cultures underlies many of the fire management techniques, tools, measures, research, technologies, principles and approaches that are applied today.[21]

Knowledge management also refers to the collection and use of statistics, reports, reviews, evaluations and other types of management systems common in businesses, governments and civil society organizations in contemporary societies. With the wide availability and use of computing and digital communications systems, the exchange of information and knowledge is becoming easier and more effective. The challenge for fire managers is to use these new systems to strengthen organizations, improve safety conditions and blend new knowledge and scientific discoveries with traditional lore and knowledge. When that is done well, both ecological and social systems benefit.

In countries where technologies are still being developed and adapted, and where there is severe resource scarcity, other approaches to knowledge management can be applied. Conversation circles in villages, social cartographies, knowledge registering and citizen science are examples of approaches that can support the collection of qualitative and quantitative data. By systematizing and standardizing information, it is possible to inform protocols, terms of use and other instruments that support sustainable fire management practices.

2.9. EDUCATION, TRAINING AND PUBLIC AWARENESS

Education and training forms a bridge between research and technical knowledge and the effective application of policies and procedures. It may be needed both within organizations and by external partners and the public. An effective programme of community engagement in IFM can help prevent unwanted wildfires, build community trust, and inform citizens of their responsibility to use fire wisely and carefully.

Community-based education can both inform citizens about IFM and – with appropriate consent – enable two-way learning with Indigenous Peoples and other local knowledge holders. The mutual exchange of traditional and scientific knowledge can be beneficial to all.

The public will be more aware of the role and uses of fire and a more effective partner when it is an integral part of the IFM programme. Public awareness must be followed by public involvement in programme implementation.

The training and qualification components of IFM provide the information and knowledge necessary to implement safe and effective programmes. Training should consider local environmental conditions and fire regimes and be available to all stakeholders.

Training programmes for volunteers and other community members must be of the same quality as those available to full-time professional firefighters, with a clear emphasis on the need for safety and caution during fire events. Special attention should be given to women and youth, whose needs may differ from those of men.

2.10. COOPERATION AND PARTNERSHIPS

Proposals for rules, procedures and standards for international cooperation on IFM continue to be developed by interested parties, including the United Nations (UN), the European Union, international organizations, government agencies, academia and civil society. These proposals constitute first steps towards the establishment of internationally negotiated and agreed standards. Selected efforts at the global level are described below.

The Global Fire Monitoring Center (GFMC) developed the Global

Wildland Fire Network as a contribution to the UN International Strategy for Disaster Reduction (UNISDR). The UN Office for Disaster Risk Reduction (UNDRR) was established in 1999 to facilitate implementation of the UNISDR with a mandate "to serve as the focal point in the United Nations system for the coordination of disaster reduction and to ensure synergies among the disaster reduction activities of the United Nations system and regional organizations and activities in socio economic and humanitarian fields" (UN General Assembly Resolution 56/195). In 2001, the UNISDR Inter-Agency Task Force for Disaster Reduction (IATF) established the Working Group on Wildland Fire (WG-4) as an interagency, intersectoral forum of UN and non-UN agencies and programmes to facilitate the creation of mechanisms of information and task-sharing to prevent and reduce the negative impacts of wildfires on the environment and humanity. The GFMC was selected to chair WG-4. Following the final report and recommendations of WG-4 and the decisions of the eighth IATF meeting, the WG-4 transitioned to the Global Wildland Fire Network and the advisory function was taken over by the UNISDR Wildland Fire Advisory Group, chaired by the GFMC.

UNEP and partners published a rapid response assessment in 2022, *Spreading Like Wildfire: The rising threat of extraordinary landscape fire,*[22] to better inform and prepare governments, institutions and communities for preventing wildfires.

In 2023, at the eighth International Wildland Fire Conference (IWFC) in Portugal, the Landscape Fire Governance Framework was presented as a global reference document for fire governance. It contains the guiding principles for adjusting fire strategies, policies and management to global change. The framework was developed by the Portuguese Agency for Integrated Rural Fire Management, in collaboration with FAO, the GFMC and the International Liaison Committee of the IWFC.

Cooperation is a means for cost-effectively spreading the fire management workload. Responsibility for IFM is often shared among several agencies in a given community or subnational or national jurisdiction. In other systems, a single agency has responsibility for IFM across all types of ownership and land use in a given jurisdiction (such as a country, a city, a district or a province), but this will still require interagency cooperation and coordination at the boundaries of the jurisdiction.

One transnational issue that will require increasingly close coordination among countries in the future is fire-related smoke (haze). One way to ensure this is to develop comprehensive, pre-fire-season cooperative agreements to facilitate cooperative activities, in which agencies agree on when, where and to what extent resources will be exchanged or sent in assistance. Such agreements usually have provisions for reimbursement; they may also include provisions to enable an assisting agency to detect and suppress a wildfire without the resources of the home jurisdiction involved at any time during the operation.

Provisions such as these can only be effective if all parties agree on the qualifications of the personnel and the methods of operation, for example the use of a standardized, on-scene operational management system such as the Incident Command System (ICS).

Perhaps the most crucial factor for ensuring cooperation is that agency administrators have confidence in the ability of partner agencies to follow procedures, conduct operations and adequately monitor, evaluate and comply with all aspects of the agreement. If those conditions are met, cooperative agreements are likely to enable effective, cost-efficient and productive cooperation. Ideally, cooperative agreements will include provision for the creation of a joint committee or other formal body to oversee implementation of the agreement, review performance, suggest and implement improvements, and ensure compliance with performance requirements.

Cooperation and partnerships are important in all aspects of IFM, not just suppression. Mutual assistance agreements are the most common form of partnership in local and international use, but many comprehensive arrangements enable a wide range of fire management exchanges and cooperation, including project planning and implementation, training, technology exchange and research.

Fire management and IFM institutions and networks have inspired the creation of the Global Fire Management Hub (the Fire Hub), which was announced during the XV World Forestry Congress and the Twenty-Sixth Session of the Committee on Forestry in 2022 and launched by FAO and the UN Environment Programme (UNEP) at the IWFC in Portugal in May 2023. The aim of the Fire Hub is to strengthen implementation of IFM worldwide to reduce the impacts of wildfires on people, landscapes and the global climate. The Fire Hub relies on the work of a broad range of national and international partners specializing in diverse disciplines, such as landscape fire ecology and history, emergency management, ground-based and remote-sensing data networks, environmental modelling, atmospheric chemistry, climatology, health research and social sciences.

The Fire Hub is based on five pillars: (1) knowledge and data sharing; (2) capacity building; (3) wildfire-resilient communities; (4) fire risk reduction and early warning; and (5) IFM policy support and implementation. These pillars are cross-cutting and connected and consider a wide perspective beyond forests. The Fire Hub will provide a "one-stop shop" for sharing data, knowledge and expertise, including guidelines, best practices, e-learning, and access to various networks and initiatives created by the global fire community.

3. Principles

The 12 principles of the IFM Voluntary Guidelines address the various dimensions of managing fire in landscapes for multiple objectives. Although the principles are grouped as social and cultural, economic, environmental, institutional, and enhanced fire management capacity, they are closely interlinked. Some aspects are listed under more than one principle to reinforce these linkages.

3.1. ECONOMIC

Principle 1. Protecting lives and assets

Minimize, if not totally prevent, the destructive impacts of wildfires on lives, property and resources.

Aspects of the principle include:

- minimizing the likelihood of damaging wildfire through knowledge, training, participatory planning and preparation, socioeconomic engagement, and appropriate suppression and mitigation systems;
- responding to unwanted wildfires promptly and safely;
- actively managing fire to protect lives, property and resources during wildfire suppression, including through the use of fire as a suppressive agent;
- operating in an environmentally sensitive manner while suppressing wildfires and restoring altered or damaged lands in order to minimize severe, long-term impacts;
- discouraging inappropriate development in fire-prone ecosystems;
- influencing the planning, construction and location of new infrastructure and adjacent vegetation to minimize the risk of damage from wildfires;
- influencing the planning and construction of roadways, pedestrian paths and other routes that will likely be used as evacuation routes during wildfires;
- influencing the planning and implementation of fire-prone activities (e.g. the use of heavy equipment, which can spark fires, or by the burning of agricultural debris) in agriculture, forestry and other sectors to minimize the risk of damage from wildfires to lives, property and resources; and
- allocating resources based on the probability of ignition and expected fire behaviour, and balancing the costs of wildfire prevention, preparedness and suppression.

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Principle 2. Economic impact

Maximize the benefits society receives from the use of fire and minimize wildfire losses, damage and other undesirable impacts by implementing an efficient IFM programme.

Aspects of the principle include:

- fully accounting for ecosystem benefits, costs and economic outputs from the use of fire for resource management and the public good;
- identifying the benefits of mitigating unwanted effects and damage to lands and resources from wildfires;
- developing and implementing all IFM strategies and fire-use programmes to maximize the environmental benefits and economic returns;
- developing methodologies and standards for quantifying positive and negative fire effects and assessing fire damage, including impacts on social and environmental values; and
- researching and understanding the socioeconomic reasons for a community's use of fire, especially if such use is not in a fire-adapted ecosystem or is found to be detrimental to the environment; and
- working with the community to find sustainable alternative techniques to fire use and to reduce the need for fire ignitions.

3.2. ENVIRONMENTAL

Principle 3. Interactions between climate change and fire

Understand and appropriately consider the interactions between climate change, vegetation and fire regimes in the planning and implementation of fire use.

Aspects of the principle include:

- estimating the impacts of regional climate change on ecosystem properties and fire regimes;
- modifying IFM plans and policies to take into account observed and anticipated changes in fuels and vegetation types, burning conditions and additional wildfire risk as a result of climate change;
- using biomass for energy production with the goal of reducing both wildfire risk and the consumption of fossil fuels;
- maximizing the storage of carbon in ecosystems – especially during the restoration of degraded ecosystems – without increasing the wildfire risk and securing the terrestrial storage of carbon;
- minimizing greenhouse-gas emissions that occur because of large-scale wildfires by restoring and maintaining ecologically appropriate fire regimes; and

- minimizing and mitigating the short- and long-term consequences of fire-induced vegetation depletion, such as soil erosion, landslides, floods, waterway pollution and desertification.

Principle 4. Fire effects on ecosystems

Manage fire in an environmentally responsible manner to ensure proper ecosystem structure, function and sustainability.

Aspects of the principle include:

- maintaining or restoring appropriate fire regimes to enhance the vigour and diversity of populations of species and communities of native flora and fauna in fire-dependent ecosystems;
- protecting fire-sensitive ecosystems;
- recognizing that strategically placed planned burning with some short-term negative environmental impacts may be necessary for long-term landscape management and community asset protection;
- applying principles of environmental management and care to the prevention of environmental disturbances resulting from IFM activities;
- planning wildfire preparedness and suppression operations within a holistic landscape view that considers archaeological, historical, cultural and traditional heritage values;
- promoting the re-establishment of ecological processes, including the restoration of native flora and fauna that may have been compromised, damaged or eliminated by fire suppression actions;
- minimizing and preventing the introduction and spread of pest or invasive plants and animals, plant diseases and biological contaminants after fires and fire suppression activities; and
- conducting planned fires in ways that minimize the spread of unwanted alien species and promotes native or other preferred species.

3.3. INSTITUTIONAL

Principle 5. Legislation

Conduct all IFM activities within an established legal framework supported by informed policies and procedures.

Aspects of the principle include:

- using these IFM Voluntary Guidelines as a basis for developing and implementing national, subnational and local legislation;
- implementing all aspects of the IFM Voluntary Guidelines appropriate in a given fire regime;

- developing guidelines for planned burning that fit within the legal framework and policies; and
- enhancing coordinated, cooperative efforts by forestry, agriculture, conservation, environmental protection, air-quality management, climatology, hydrology, land-use planning and other sectors in implementing IFM.

Principle 6. Policymaking

Take an integrated approach to policymaking for fire management.

Governments and government agencies are encouraged to move from arrangements in which each governmental institution works vertically, focused on their sectoral mandates, to integrated approaches to policymaking, with broader, cross-sectoral and multistakeholder solutions and shared responsibilities and budgets, building on good practices already established in many countries. Integrated fire management policies derived from inclusive review, analysis, consultation and consensus are most likely to be effective and long-lasting.

In the national context, including existing laws and cultural heritages, fire management should be guided by a sound set of principles to which all stakeholders can adhere, thereby creating trust and certainty and facilitating positive change.

Key elements of the principle include:

- taking actions to obtain results for the benefit of citizens and their material, cultural and historical heritage and to safeguard health and safety, sources of livelihood and economic, social and environmental values, taking into account longer-term impacts;
- undertaking risk assessment and evaluation to enable incorporation of multiple future scenarios;
- considering and involving local community knowledge and management in policymaking, strategic planning and decision-making processes to best address fire at the landscape level;
- gradually transforming existing governance models to enable specialization of the most needed skills as institutional rearrangements take place;
- enabling actions to evolve according to the capabilities of each response level, activating subsequent higher levels when needed;
- committing operational forces in accordance with current conditions, prioritizing suppression when necessary and preventative actions before fires start, especially when potential for the ignition and progression of fires is extreme;
- using resources and their translation into action efficiently, ensuring that actions comply with quantifiable and measurable objectives;

- ensuring that agents involved in all actions hold the qualifications necessary to carry out assigned missions at any time in response, technical, directing, commanding or operational duties;
- ensuring that agents have access to the material resources necessary to succeed and to health conditions suited to their missions, at all levels;
- planning and developing operations according to needs, as determined by the analysis of meteorological information and foreseen circumstances, seeking to apply sufficient resources to the response and its previous movement in space and time;
- ensuring that all procedures are auditable and performed according to established and clearly identified criteria, and justifying and publishing the motivation for performing any acts;
- analysing and evaluating all agents and their actions with a view to continually improving the system and agents, and feeding the information gained into a lessons-learned system;
- enabling agents to develop IFM actions in a manner that considers the history of the country, its institutions, and all those who have been severely or fatally affected by wildfire;
- considering the development of national fire management plans during development of individual, institutional and sectoral planning;
- basing policy and strategic planning and related decision-making on sound, multidisciplinary scientific knowledge and in light of technological capabilities and innovation, including the appropriate use of traditional, socioeconomically sound, and environmentally benign land-use practices;
- encouraging greater coherence among the fire management mandates and activities of state institutions and other stakeholders to efficiently and effectively implement overarching national fire management policies and implementation plans; and
- coordinating and monitoring, on a permanent basis, the implementation of actions under fire management plans.

Principle 7. Multistakeholder approach

Use participatory approaches to leadership and management of IFM that are appropriately shared by public and private landholders, fire services, local communities and interest groups.

Key elements of the principle include:

- minimizing the incidence of human-caused wildfires;
- meeting integrated land management objectives such as safety and environmental and resource management;
- recognizing the role of local communities and land managers in fire-related and other land-use issues;

- ensuring a coordinated approach to effective IFM in areas where multiple organizations and stakeholders have responsibilities and interests;
- recognizing and using the knowledge, leadership and expertise of local citizens and community groups;
- involving community members at the local, subnational, national, regional and international levels to ensure that processes are open and accessible to people of different backgrounds and cultures (especially Indigenous Peoples and other local knowledge holders);
- encouraging cross-sectoral participation in the development and implementation of plans, including communities, land managers, fire agencies, emergency services, enforcement and medical agencies, non-governmental organizations and the media;
- acknowledging that IFM plans and wildland fire at the local level can have international and global impacts on the environment;
- understanding the differing backgrounds and roles of urban and structural fire services and land management and rural fire services, and using each to the best advantage based on their strengths;
- recognizing that land management as it relates to landscape fire is a multidisciplinary field and should include viewpoints and evidence from diverse biological disciplines, such as soil science, hydrology, geology, forestry and ecology;
- using reference documents, such as the IFM Voluntary Guidelines, the Landscape Fire Governance Framework[23] and *Health Guidelines for Vegetation Fire Events*, to better guide managers, firefighters, residents, politicians and institutions[24,18]; and
- training and equipping volunteer groups and community and rural groups to enhance their roles and effectiveness in IFM.

3.4. SOCIAL AND CULTURAL

Principle 8. Sustainable livelihoods

Appropriately use and manage fire to promote sustainable livelihoods.

Aspects of the principle include:

- allowing and promoting the appropriate management and responsible use of fire for sustainable silviculture, agriculture, livestock and watershed management and biodiversity conservation, and balancing these with the need to protect people, communities, organizations and governments from the harmful effects of wildfire;
- actively planning and undertaking fuel reduction programmes as effective methods for wildfire prevention and reducing wildfire risk, including

targeted prescribed grazing and the use of biomass as an alternative, sustainable source of energy to replace fossil-fuel use;
- promoting the use of planned fire across landscapes to restore or maintain natural fire regimes and, where appropriate, facilitate land management and reduce the risk of large-scale, destructive wildfires;
- allowing natural fires to burn in an appropriate range of frequency, seasonality and intensity in fire-dependent ecosystems for economic and social benefits, as well as to maintain habitats and reduce the cost of suppressing wildfires;
- wherever possible, replacing the use of fire for agroforestry with environmentally friendly and sustainable mechanisms in fire-sensitive ecosystems and when fire danger ratings are high;
- promoting the effective monitoring and evaluation of the multidisciplinary impacts of planned fires and wildfires; and
- actively suppressing wildfires that threaten assets and sustainable livelihoods.

Principle 9. Human health and safety

Improve human health and safety by minimizing the adverse effects of wildfire.

Aspects of the principle include:
- ensuring public health and the safety of firefighters, fire managers and civilians during all fire management activities;
- maintaining and supporting an effective wildfire prevention programme that minimizes the number and impacts of destructive wildfires;
- developing or adapting existing fire danger rating systems, in conjunction with reliable weather forecasting, to provide hazard and risk assessments to national agencies, landowners and communities;
- using early detection and early warning systems to reduce the health and safety impacts of wildfires;
- providing education and training to at-risk communities;
- conducting community-based risk-reduction activities at all stages of fire management, including pre-fire, during fire events and post-fire;
- considering the balance of negative and positive effects on communities when using fire as a land management tool;
- empowering communities to be responsible for managing fire and its effects on their health, safety and welfare;
- developing or updating community infrastructure, such as inefficient or unmarked evacuation routes, to minimize the most adverse direct public impacts of wildfire, including human mortality during wildfire evacuations; and

- developing community infrastructure, such as clean-air shelters and catch-basin/retention ponds, to minimize the most adverse secondary impacts of wildfire, smoke and post-wildfire hazards.

Principle 10. Traditional uses of fire

Engage Indigenous Peoples and other local knowledge holders to enable access to practices and experience for the benefit of all.

Aspects of the principle include:

- working with Indigenous Peoples and other local knowledge holders to support their traditional use of fire and the prevention and mitigation of negative impacts on them and their lands, territories and resources;
- working with Indigenous Peoples and other local knowledge holders with the aim of developing IFM programmes that include their knowledge and practices, with their free, prior and informed consent as a right of Indigenous Peoples and good practice for local communities; and
- maintaining a range of landscapes and environments that provide a diversity of habitats, species, resources and opportunities for recreation, commerce, community enjoyment and cultural and religious practices.

3.5. ENHANCED FIRE MANAGEMENT CAPACITY

Principle 11. Cooperation

Develop cooperative arrangements to mitigate the transboundary impacts of fire because no single country, agency or community can manage every situation and fires routinely affect multiple jurisdictions.

Aspects of the principle include:

- encouraging the use of common terminology, systems and standards to enhance international cooperation;
- promoting the ongoing exchange of knowledge, technologies and resources to facilitate rapid international responses to wildfires;
- participating in international organizations, networks, fora and activities to enhance domestic and international capacities and rapid international responses; and
- using available guidelines and examples of successfully implemented agreements as a framework for the development of binding and non-binding international instruments.

Principle 12. Knowledge transfer

Ensure access to, and appropriate application of, knowledge in all IFM activities.

Aspects of the principle include:

- engaging in the creation of new knowledge with scientists, Indigenous Peoples and other local knowledge holders to support the creation or improvement of policies, regulations, guidelines and practices;
- working with Indigenous Peoples and other local knowledge holders who have knowledge about the environment and the historical use of fire;
- providing personnel involved in fire activities with appropriate opportunities to develop their knowledge and skills to ensure their competence for their roles and tasks;
- incorporating effective communication and providing community education on IFM to enhance community preparedness and response;
- working with Indigenous Peoples and other local knowledge holders in all aspects of IFM, respecting the good practices of communities traditionally inhabiting an area and the rights of Indigenous Peoples, as enshrined in the UN Declaration on the Rights of Indigenous Peoples, particular the rights to self-determined development and to free, prior and informed consent;
- communicating, as needed, that properly applied and managed fire can generate ecological, cultural and economic benefits; and
- translating scientific, research and technical materials to make them accessible, at the appropriate level, to local managers, firefighters and communities.

4. Strategic actions

The strategic actions indicated here are intended to assist land-use planners, land managers, landholders and Indigenous Peoples and other local knowledge holders in implementing IFM. They may also be used as a checklist to assess organizational capacity.

4.1. INTEGRATED FIRE MANAGEMENT IN NATURAL AND PROTECTED AREAS AND RESERVES

Integrated fire management can be applied in diverse environments (e.g. forests, woodlands, rangelands, savannahs, shrublands, grasslands and peatlands) and in areas designated for production, conservation or cultural activities or as protected areas and reserves. The same general approach to IFM planning should be followed in all cases, taking into account the specific management objectives and in the understanding that operational standards and actions may vary accordingly.

The key consideration is the formulation of strategic actions for the management and protection of each area. Threatened species, Indigenous sacred sites, water resources, scenic and recreational areas, and other elements all have economic, social and environmental values that must be considered in the development of IFM plans.

Protected areas may require special consideration in fire suppression and planned fire; for example, fire personnel may be required to use specialized tactics and suppression techniques in these areas. In many sensitive areas, the use of heavy mechanized equipment can be damaging to the environment – potentially, it can affect the values of an area more than fire. In all cases, a balance should be reached in the amount and type of fire, the types of prevention and responses, and the impacts on the area.

Strategic actions for IFM in natural or protected areas and reserves may include the following:

- Integrated fire management plans and guidelines should identify the unique character of, and objectives for, the area, considering the role that fire plays in restoring or maintaining this unique character.
- People living in protected areas should be consulted in a respectful and inclusive way and in line with existing laws, and their rights should be guaranteed and no interference made with their ways of life to enable them to participate actively in IFM activities.
- In areas that require periodic fire to restore or maintain their unique character, the potential for fire to affect resources, communities and people outside the area should be considered.

- Plans, guidelines and operational procedures should be developed with a view to mitigating unwanted or damaging impacts of planned burning.
- Care should be taken to ensure that invasive plants and diseases are not introduced through fire suppression actions and the use of fire equipment and machinery.
- When fires occur in fire-sensitive areas, or when a particular wildfire incident is uncharacteristically severe or damaging, suppression tactics should be planned and implemented with a view to mitigating any arising damaging effects on the protected area.
- Where fire-dependent natural areas are located near economically valuable assets such as infrastructure and agricultural and forestry land, detailed plans should be developed to minimize the impacts of IFM activities on those assets.

4.2. FIRE AWARENESS AND EDUCATION

Given that many landscape fires globally are human-caused, involving communities and groups in IFM programmes and engaging them as responsible partners is essential. A well-informed public will be more likely to understand and use fire carefully and to adhere to policy and legal boundaries. Communities can assist in the prevention, detection and reporting of fires, work with fire personnel to control unwanted fires, and provide sources of local and traditional knowledge.

A programme of awareness and education can be provided to schoolchildren through structured sets of lessons and learning objectives. Programmes should also be developed for adults and communities to educate them, communicate changes in policies and increase understanding of the role of fire and the impacts of unplanned fires on ecosystems and resources. Successful media campaigns, based on sound technical knowledge and research, have used print media, radio and television to spread messages on wildfire prevention and the proper use of fire, as well as to warn of conditions in which extreme wildfires might occur.

Strategic actions for fire awareness and education may include the following:

- Fire awareness and educational programmes should be developed and targeted at specific audiences and communities.
- Programmes should be sensitive to the cultural and social norms of communities, including the use of fire for agricultural, forestry, biodiversity conservation and traditional purposes and to meet other needs.
- Socioeconomic pressures must be understood, and a search for solutions should include affected communities and alternative economic incentives that will enable positive change.
- Fire awareness and educational materials should be gender-sensitive and reflect local literacy levels. Oral presentations should be considered in contexts where printed materials and other media may be ineffective.
- Age-appropriate information and educational materials should be developed jointly by technical experts and educational specialists and provided to introduce ecological and IFM concepts to local schools.
- Primary and secondary schools, universities, non-governmental organizations and other institutions should be encouraged to develop locally appropriate educational materials on IFM for use by teachers and other educators, based on local conditions and beliefs.

4.3. WILDFIRE PREVENTION

Preventing unwanted damaging fires is always less costly than suppressing them. Prevention programmes that are accepted and promoted in a community will not only reduce costs and resource damage but also promote understanding of the role and impacts of fire in the ecosystem.

Wildfire prevention applies to human-caused ignitions and requires a combination of community education, effective prevention programmes and the enforcement of laws and regulations. In fire-dependent ecosystems and cultural areas, allowing some fires to burn within defined parameters may be beneficial, although it may complicate efforts to enforce prevention regulations.

Planned fire is a component of wildfire prevention in many parts of the world. It can have significant beneficial impacts on wildfire risk, intensity, severity and damage and assist firefighters in suppressing fires. Planned fire can also be beneficial for ecosystem sustainability, maintenance and restoration. The role of fire in sustaining and restoring ecosystems is further addressed in section 4.12.

Strategic actions for wildfire prevention may include the following:

- In areas where the objective is to minimize the number of fires and the area burnt, a comprehensive prevention plan should be developed.
- Prevention plans should take into account traditional uses of fire, be based on laws and regulations restricting fires, and involve local communities and organizations.
- Data should be collected on a monthly and annual basis about fire occurrence, the specific causes and locations of human-caused fires, the reasons for starting fires, and the area burnt.
- Wildfire prevention programmes should include information on the need to use and manage fire in certain situations.

4.4. FIRE DANGER RATING AND EARLY WARNING SYSTEMS

Fire danger rating systems (FDRSs) have long been used to determine the level of fire hazard and risk and to provide early warning of the potential for extreme burning conditions and threat to values at risk. These systems use daily (and hourly, when available) fire weather data to estimate fuel moisture and expected fire behaviour. By using fire weather forecasts, FDRSs provide early warning of extreme burning conditions when wildfire disasters typically occur. The length of time of advanced fire early warning is dependent on the length of the fire weather forecast.

Locally generated early warning information will best reflect local weather characteristics and vegetation conditions. The active involvement of local communities in collecting fire-weather information and disseminating warnings creates a sense of local ownership and local responsibility and improves the efficiency of the early warning system.

Forest and land management agencies, landowners and communities will benefit from early warning systems that identify coming critical periods of extreme fire danger. Such early warnings, particularly if delivered with high spatial and temporal resolution and incorporating measures of uncertainty and the likelihood of extreme conditions, allow fire managers to implement wildfire prevention, detection and preparedness plans in advance of high-fire-danger conditions.

Strategic actions for fire danger rating and early warning systems may include the following:

- To support large-scale (landscape-level) IFM decision-making, countries and organizations should establish FDRSs or adapt existing systems to local environments by calibration based on historical weather data. For small-scale (stand-level) IFM decision-making, fire behaviour prediction systems can be developed or adapted by combining weather-based fire danger ratings with information on local fuels (vegetation), land cover and topography.
- The development of national or even regional-scale early warning systems can assist in enabling coordinated preparations for periods of high fire danger in countries and regions.
- An information network should be developed, taking advantage of established community networks, to provide local authorities, landowners and communities with reliable early warning of fire danger. Training communities in the use of appropriate technologies is crucial for ensuring that everyone knows how to access the information and the various stakeholders are aligned during emergencies.
- Education programmes should be undertaken on fire danger ratings to ensure that the public is aware of the fire danger on any given day and understands the potential consequences of landscape fire ignitions (intentional or not).

4.5. FIRE PREPAREDNESS, INCLUDING TECHNICAL TRAINING

Fire preparedness includes the detection and mobilization (pre-positioning) of suppression resources before a wildfire occurs, as well as training, staff planning and the provision of appropriate equipment. An effective fire preparedness programme should be based on IFM planning, which includes consideration of all land resources, stakeholders and values at risk and should take into account year-to-year variations in funding, weather and human activities. Ensuring that properly trained and equipped personnel are present at key locations will increase the effectiveness of the programme.

The safety of firefighters is dependent on their understanding of fire characteristics and local weather; good training in these aspects, therefore, is a key part of fire preparedness. Training on the effective use of equipment and fire suppression techniques is also important, and supervisors and managers should be well trained on the effective deployment of suppression resources.

It is essential to provide firefighters with proper protective equipment, such as helmets, gloves, fire-resistant clothing and safety boots. The tools provided must be within the financial resources of the programme, culturally and gender appropriate, and effective in the environment in which they will be used. The proper maintenance of tools and equipment is part of preparedness.

Strategic actions for fire preparedness plans should include the following:

- all activities to be undertaken before the start of a fire;
- safety considerations for both firefighters and the public;
- an efficient mix of agency resources;
- ecological considerations, such as the impact of suppression actions on the environment and the role of fire in the ecosystem or in cultural areas;
- processes and procedures for assessing risk and hazard and determining appropriate response and mitigation actions;
- establishing pre-suppression resource levels based on predicted fire risk;
- assessment of capability of remote communities and individuals living in outlying areas to protect their assets and assist fire services in all phases of IFM;
- training appropriate to local ecological, social and political conditions, delivered to the same standard for professional and volunteer workers for the expected fire characteristics.

4.6. OTHER PREPARATORY ACTIVITIES

Additional activities may need to be undertaken before the beginning of a fire season, or – in regions with no distinct fire season – before predicted periods of elevated fire danger. These could be characterized as preparedness actions but are differentiated from the previous section, which deals with actions to prepare resources for response. Pre-fire season activities involve cooperative action with collaborators, contractors and other groups and organizations in support of the IFM programme.

In many situations, formal agreements between partners will provide a clear understanding of the roles and responsibilities of each. Such agreements can take the form of enforceable contracts, or they could be memoranda of understanding indicating the general areas in which cooperation and coordination will take place.

Agreements could specify the convening of annual meetings, which can be an effective means of communication for ensuring that all parties and personnel receive consistent information and come to mutual understanding. Such annual meetings can be expanded to include exercises and simulations, the testing of communications equipment, and practising fire suppression techniques.

Strategic actions for pre-fire season activities may include the following:

- All parties to an agreement should hold annual pre-fire-season meetings to review the agreement and discuss changes and improvements to annual operating plans.
- Before the start of a fire season, efforts should be made to inform the public of fire preparedness plans and procedures and provide advice on public safety.

- Arrangements with landowners should be established if access through their properties might be required for IFM activities, including fire detection.
- Agreements should be made with utility companies, communication and transportation agencies and other affected sectors to facilitate coordinated suppression actions in the event of wildfire and minimize the risk to firefighters, the public and infrastructure.
- Annual exercises and simulations, with an established evaluation methodology, should be a part of IFM preparedness programmes to ensure the readiness of involved parties and provide information on the capacity and capability of each party.
- Annual public landscape fire awareness, evacuation and protection simulations should be held to ensure that all residents in a community understand evacuation procedures and the best way to ensure their safety in the event of a wildfire.

4.7. FIRE DETECTION, COMMUNICATIONS AND DISPATCH

Fire detection is an important part of IFM, and it can be accomplished using one or more of fire observation towers, aerial surveillance, thermal cameras and artificial intelligence, lightning detection systems, satellite imagery and sensors, and monitoring and reporting by local people. The latter is an increasingly effective means of fire detection as mobile phone coverage increases and as more local residents understand the risk posed by wildfires and participate in community-based fire management programmes.

Once fires are detected, effective communications are needed to provide firefighters and managers with information on the fire's location and size and the burning conditions. Dispatch centres should be equipped to operate with backup energy sources: their function is to receive information on fire ignitions and location and to alert fire suppression personnel and dispatch them to the fire, as appropriate.

Dispatchers provide firefighters with up-to-date information on changes in weather forecasts, fire behaviour, strategy and incident command structure. They monitor the fire situation and receive orders from the incident controller or commander for additional and backup resources.

Communication is also needed with the public to inform it of the fire status and any threats to the community. Local media, including radio, television and the press, as well as other traditional methods and emerging technologies for information dissemination, should be part of the communications plan. The local public should be educated on IFM terminology, procedures, and what they should do in case of an immediate evacuation order.

Strategic actions for fire detection, communications and dispatch may include the following:

- A robust fire detection system should use an appropriate combination of remote sensing, appropriate established ground- and aerial-based detection infrastructure and patrol routes, and private citizens' and rural community networks.
- A dispatch and communications system should be in place to determine the appropriate response to a reported fire, mobilize and support initial-attack and backup fire suppression resources, and provide appropriate information to responders, volunteers, landowners and others involved in the incident response.
- A public communications plan should be developed and translated into local languages to inform the public of threats and potential severe fire conditions and to convey prevention messages.

4.8. INITIAL ATTACK

Initial attack (also called first response) is the first phase of fire suppression, and its success or failure may determine the success of the entire IFM programme. If initial attack is successful, this indicates that most other programme elements have also been successful. Initial attack is less likely to succeed in the absence of appropriate planning, policies, prevention, fuel management, community involvement and detection.

Initial-attack strategies and tactics should be designed to fit the local situation. Strategies based on local conditions, objectives and budgets will determine the number, type and location of suppression resources, such as crews, suppression equipment, vehicles and aircraft. The IFM plan should provide firefighters with clear instructions on how fires are to be fought, whether some are to be allowed to burn to benefit the environment and resources, and the tactics and strategies to be used to protect ecosystems. Initial-attack actions should be based on expected fire behaviour, difficulty of control, and availability of suppression resources.

There are several ways to provide initial-attack capability. Individuals, either by choice or because of the lack of other wildfire protection service, can take on the responsibility using their own assets. Groups or agencies can be formed, funded, staffed and equipped by a government or other organization. Members of local communities can organize to establish response groups and be trained as first responders to fires. Volunteers may also form an integral part of a fire organization, supplementing a small core of permanently employed staff that perform equipment maintenance, readiness activities, and leadership roles during suppression actions. Fire crews and resources should use a standardized operational system, such as the ICS (see Appendix 2), which allows professional staff from multiple diverse fire and emergency response

agencies to work together as a single, organized unit. The ICS can provide the basis for establishing a fire overhead team for command and control that is flexible and can expand to manage fires that become larger and more complex.

Strategic actions for initial attack may include the following:

- Involved personnel should be properly trained, equipped, supported and staffed to meet local requirements.
- Initial-attack actions should be based on available fire suppression resources and cultural, economic and ecological objectives and policies for the area, including the appropriate use of tactics and equipment.
- The arrangements for initial attack should work with local communities, where possible, to build support within the community for IFM policies and plans and to gain from local knowledge and experience.
- The initial-attack organization should have access to communications systems to receive timely information on fire starts, locations and status from official sources and the public.
- The fire management organization should be trained to rapidly adapt suppression tactics if the wildfire escapes initial attack and continues to grow in size and intensity.
- Based on the requirements of the legislative framework, the fire management organization should be prepared to assist with additional wildfire emergency activities such as protecting citizens, homes and public infrastructure and directing evacuations and should be trained in rescue and emergency medical procedures.
- The initial-attack organization should be trained to collect data and prepare evaluations and reports to improve organizational effectiveness and to work with the media in keeping citizens informed.

4.9. LARGE-WILDFIRE SUPPRESSION AND MANAGEMENT

A low-intensity, slow-spreading wildfire can quickly transform into an uncontrollable fire when environmental or meteorological conditions change. When initial-attack resources are unable to contain a wildfire, a transition in suppression tactics is required from initial attack to extended attack (or "sustained action").

The management of large fires can be very different during the transition from initial attack to sustained action. A "large-wildfire event" is not defined so much by the size of the fire as by its complexity, duration and threat to values at risk. As increasingly higher suppression resource levels are required to contain, control and eventually extinguish these high-priority wildfires, suppression planning and actions often transition from the main fire agency to an overhead team dedicated specifically to that wildfire. In effect, the overhead team and all resources committed to that fire become a separate sublevel fire management organization.

Managing and coordinating the large numbers of people and equipment in high-priority wildfires requires a higher-level command structure. Standardized, on-scene operational management systems, such as the ICS and the Australasian Inter-service Incident Management System (AIIMS), have been developed to be used in any type of emergency incident at any level of complexity and are effective operational fire management tools.

Strategic actions for large-wildfire suppression and management may include the following:

- Plans and procedures should be established for large-wildfire suppression based on expected size, duration and complexity.
- A well-planned process should be in place to gather intelligence and information on all aspects of a large wildfire to ensure effective planning, strategy formulation and community involvement.
- A versatile and expandable incident management system, such as the ICS, should be used to manage fires of all sizes and complexities in order to minimize confusion and risk during transition periods.
- Pre-fire-season agreements should be prepared among agencies, including emergency services, transportation agencies and others that enable the provision of additional assistance during large fires when local resources are fully committed.
- A process of review, evaluation and training should be in place so that fire suppression personnel recognize the conditions under which a large wildfire is likely to occur and to ensure that prompt and adequate steps are taken in anticipation of the event.
- Information on vegetation type, fuel load and continuity, natural barriers to fire spread (e.g. lakes, rivers and burnt areas), topography and access routes should be used to determine suppression tactics.
- Suppression plans should contain provisions for evaluating large wildfires to determine whether the fire can be managed in a manner that benefits the ecosystem, reduces the risk to fire suppression personnel, and minimizes costs.
- Plans should include analysis of the probability and consequences of failing to meet the plan's objectives.

4.10. MANAGING MULTIPLE INCIDENTS

Some of the most difficult and complex situations occur when multiple fires start simultaneously or when additional fires are discovered before the initial ones are brought under control. Such situations become further complicated when the fires occur across several jurisdictions with differing legislative or institutional management objectives.

In periods of multiple fires, fire suppression resources may be depleted, requiring managers to allocate resources based on priorities and potential threats. Protection priorities often vary widely, which makes it difficult to

determine where fire suppression resources should best be deployed. Moreover, deployment decisions often need to be made with inadequate information. Setting up procedures in advance reduces the risk to health and safety and the potential damage to land resources and communities.

An effective way to manage priority setting during periods of multiple fires is through a coordinating group, established beforehand, comprising senior managers from the agencies involved, including community organizations. The coordinating group will meet during the emergency to set priorities and address major areas of concern. This group should also convene in non-emergency periods to discuss and agree on issues such as standards, objectives, priorities and procedures for coordination and mutual assistance during emergencies. This should include agreement to use a standardized, on-scene operational management system such the ICS or AIIMS.

Strategic actions for managing multiple incidents may include the following:

- Before the start of the fire season, plans should be developed for the management of multiple-fire events, addressing, for example, resource allocation, prioritization and interjurisdictional coordination.
- A group comprising senior managers across agencies and jurisdictions, including community organizations, should be established to decide on protection and resource-allocation priorities through coordinated management direction and policy implementation.
- Consideration should be given to the possibility that suppression resources committed to sustained action at ongoing wildfires will need to be available for initial attack at critical periods to prevent the initiation of additional high-priority wildfires.
- Standardized, on-scene operational management systems should be used across jurisdictions and in response to any type of wildfire or other emergency to facilitate coordination and scaling-up across jurisdictional boundaries and in multiple-fire events.

4.11. FUEL MANAGEMENT

In this section, "fuel management" refers to all methods of fuel treatment and alteration for any purpose – that is, wildfire risk reduction, community protection, ecosystem restoration, and debris removal following logging or another activity. Mechanical treatments are those methods of moving, altering the arrangement of, compacting or manipulating in any other way fuels using either mechanized equipment or manual labour. Any activity that changes the arrangement or composition of fuels should be considered part of the fuel treatment programme. The application of chemicals, and resource management activities such as grazing and timber harvesting, will change fuel beds. Such actions should be planned and implemented with full consideration of the potential to change fire intensity, spread and damage.

Fuel treatment can be an important part of community protection programmes, especially where homes and other infrastructure are adjacent to fire-prone vegetation. Homeowners can assist by removing brush and debris on their properties, including by using carefully planned and implemented fires. Although fuel treatment may not reduce the occurrence of a fire, it will reduce fire intensity and thus increase the effectiveness of wildfire suppression tactics and reduce the risk of property losses.

Strategic actions for fuel management may include the following:

- Fuel management should be part of an IFM programme.
- Studies should be conducted to understand the structure, growth and cure dynamics of the fuels in place and to help in deciding how to manage them.
- Fuel management should consider the potential uses of debris and vegetation and, where appropriate, encourage local communities to use wood for fuel and perhaps grasses and shrubs for grazing or other community needs.
- Plans to use mechanized equipment should assess the potential for the equipment to harm the environment and attempt to mitigate this potential or ensure that the benefits outweigh the potential risks.

4.12. PLANNED FIRE/PRESCRIBED BURNING

Planned fire, prescribed fire and prescribed burning are synonymous and define the deliberate use of fire to meet specific management objectives. It can be either a management-ignited fire or a wildfire that burns within prescription, which means it will meet management objectives, such as to reduce fuel loads (live or dead), promote the growth of pyrophytic plants, recycle nutrients back to the soil, among other objectives. This section encompasses the use of planned fire for all IFM purposes.

Planned fires can be an effective way to remove unwanted vegetation for a variety of objectives. The use of fire is well established as a tool for agriculture, forestry, animal husbandry and land clearing around the world, and it is also important in maintaining healthy fire-dependent ecosystems, where natural fire plays a beneficial role and should be encouraged or managed as part of an IFM programme. The terminology used to define the types of planned fires and techniques differs between countries and regions, making comprehensive, multilingual glossaries essential for facilitating transboundary planned-fire management and a common global understanding.

In fire-adapted ecosystems, and cultural areas, fire is an essential part of the life cycles of many plant species and therefore of many fauna species, too. If the goal is to maintain or restore sustainable ecosystems and cultural areas, allowing burning for restoration and rehabilitation should be part of the overall IFM programme.

A crucial aspect of any prescribed-burning programme is mitigating the effects of smoke, especially in areas with legal mandates to provide clean air and protect citizens from respiratory threats and where smoke naturally accumulates to unhealthy levels around population centres. An important element of smoke-hazard mitigation is developing a good working relationship with a weather forecasting service, which can provide guidance on the likely airshed impacts from prescribed burns in specific areas under given weather conditions.

Strategic actions for planned fire may include the following:

- The impacts of planned burns on human health and air quality should be considered.
- Studies should be conducted (e.g. by teams comprising scientists, managers and local knowledge holders and Indigenous Peoples) to monitor the effects and consequences of planned fires and to guide the implementation of appropriate fire management to achieve specific goals. In conducting studies and monitoring, efforts should be made to incorporate the views and perceptions of different gender identities and age groups and ensure wide participation.
- Long-term ecological studies are essential for accurately determining the effects of fire regimes on vegetation, flora and fauna.
- Before reintroducing planned fire to a landscape, consideration should be given to the impacts of long-term fire exclusion on resources, vegetation and ecosystem and human health.
- Based on the complexity and potential risk, planned burns should be undertaken only after plans have been developed that consider operational procedures for safe work practices, predicted environmental effects, and the expected fire behaviour needed to produce the desired effects.
- The results of burns should be assessed and used to revise operating plans, procedures, environmental parameters and contingency plans.
- A contingency plan should address the potential of fires to escape and damage resources, property, habitats and communities and to threaten the safety of fire management personnel and the public.

4.13. BURNT AREA REPAIR, REHABILITATION AND RESTORATION

Burnt area recovery can be divided into three categories: (1) repair of damage caused by suppression efforts; (2) measures to assess and reduce risk to lives, property and resources; and (3) the longer-term rehabilitation and restoration of the burnt area and infrastructure.

Immediate rehabilitation actions can be undertaken in conjunction with fire suppression actions as part of the post-fire recovery phase. For example, a fire line constructed along a steep slope may be prone to erosion and further damage if immediate steps are not taken to interrupt the flow of water along it.

Other hazards include soil erosion, the degradation of habitats and water resources, and the spread of invasive weeds, pathogens and other exotic pests. Therefore, there is potential for suppression actions to cause long-term impacts on soils, water bodies, wetlands, sensitive species and habitats, and cultural resources, and steps should be taken to minimize the risk of these and to quickly repair any damage caused. Common repair methods include scarification and scattering of woody material on fire lines and in other cleared areas, controlling erosion in disturbed areas, especially those adjacent to streams, lakes and wetlands, and weed eradication.

Engaging suppression crews in rehabilitation activities can have the benefits of informing them of the potential for suppression techniques to cause damage and educating them on the need to mitigate this potential during suppression actions. For example, a crew using hand tools to construct fire lines can do so in a way that directs water flow off the lines to reduce the potential for erosion.

Wildfires cause changes to watershed conditions that can increase the threat of flooding and landslides for several years afterwards. As the fire is being controlled, the burnt landscape should be evaluated for post-fire risks to lives, property and resources and steps taken where possible to mitigate these. Threats that exist or are amplified in a post-fire setting include accelerated soil erosion and runoff that can, in turn, lead to increased sediment transport and deposition; larger and more rapid floods and debris flows; landslides; and rock falls. Scientists have learned that the impact on soils (versus impacts on vegetation) is the most important indicator of potential post-fire watershed response and recovery. Therefore, a field validation of soil conditions should be completed as a crucial component of any assessment. Mitigation measures might include public education on post-fire threats, safety alerts for floods and landslides based on rainfall thresholds, and constructed treatments for the protection of property.

Rehabilitation and restoration activities include actions taken to return the landscape to a pre-wildfire condition. These actions include control of exotic species, replanting, reforestation, and repair of infrastructure. Replanting and reseeding in sensitive areas can reduce the risk of colonization by invasive species that would otherwise take advantage of the large expanses of exposed soil.

In planted and natural forests in which commercial activities are planned, economic considerations may dictate that an aggressive salvage programme be undertaken to harvest timber and other products, followed by a reforestation effort. Economics may be the overriding consideration where communities are dependent on forests as a source of revenue and livelihoods.

Strategic recovery actions may include the following:

- Every fire suppression plan should consider the need for timely corrective actions to mitigate damage to the resource resulting from suppression actions such as firebreak construction and other ground-disturbing activities. Such actions should be undertaken before the suppression resources leave the fire area.

- Burnt area emergency response plans should be based on an evaluation of post-fire soil and watershed conditions.
- Where possible, mitigation measures should be taken to prevent the loss of lives and property in post-fire flood and landslide events, including through public education and warning systems.
- Burnt area rehabilitation and restoration plans should be based on the planned or natural fire regime in the area with a view to ensuring a healthy, sustainable ecosystem or cultural area.
- Where natural processes are not expected to provide adequate regeneration, rehabilitation plans should be developed that include the active planting or seeding of plants (e.g. trees, shrubs and grasses) native to the ecosystem that will assist ecological recovery.
- Care should be taken to ensure that seed sources are reasonably free of contaminants such as the seeds of invasive species.

4.14. RESOURCE MANAGEMENT AND INTEGRATED FIRE PLANNING

A legal, institutional and policy framework should be in place to provide the basis and structure for strategic and tactical planning and implementation actions as part of fire and resource management planning. The framework should include broad, multisectoral resource management plans for the management, protection and restoration of land and resources. Generally, a resource management plan does not determine the use or designation of an area; rather, it sets out the activities and procedures to be undertaken to enable institutions and individuals to carry out legislative requirements. Adequate indicators would be needed to provide information related to measuring the effects of fire management from socioeconomic and environmental perspectives and enable their adaptation in light of evidence.

An IFM plan is one level below a resource management plan because it is dedicated to fire issues and will be planned for one or more years consistent with it, although it is possible to develop the former without the latter in place. An IFM plan encompass all the issues described in this chapter (i.e. sections 4.1–4.17). In some situations, it may be best to develop individual plans for certain issues, such as wildfire prevention and suppression, education and awareness, capacity building, vegetation restoration and the use of planned fire. However inclusive an IFM plan, safety should be a principal component. For an IFM plan to be inclusive, realistic and effective, the participation of all stakeholder groups is crucial, especially women, youth, local knowledge holders and Indigenous Peoples. Given projections of increasing climatic variation, IFM plans should include planning for extreme weather events. Resource allocation, prioritization and community engagement in periods of severe wildfire danger are key for protecting people and assets.

Strategic actions for fire and resource management planning may include the following:

- All IFM plans and activities should be based on a clear and comprehensive policy, legal and institutional framework.
- Plans should be prepared at an appropriate level of detail for every aspect of IFM, with sections on, for example, review and analysis; risk reduction; readiness; response; recovery and restoration; and the landscape fire governance framework.
- Participatory approaches should be used to validate the plans of, and include the knowledge and perceptions of, local residents, firefighters, scientists, Indigenous Peoples and other local knowledge holders, and others, as well as to promote sound collective planning.
- Policies should be established that set the safety of firefighters, fire managers and the public as the highest priority.
- In areas where multiple agencies or organizations have fire management responsibilities, a process should be developed to determine who will assume the lead role and duties in the event of a wildfire.
- Resource management plans should include analysis of actions that will increase or decrease the risk and hazards affecting fire behaviour and impacts as well as risks to the safety of firefighters, fire managers and the public.
- Integrated fire management plans should be based on the ecosystem types, potential fire effects, fire regimes, and economic, social and environmental values.
- Integrated fire management plans should provide for infrequent but potentially damaging wildfires and should include analysis, planning and identification of the resources and potential operational actions required.
- Integrated fire management plans should be based on climate, realistic weather forecasts and the effect on fire behaviour and suppression effectiveness.
- Organizations, agencies, governments and communities should develop processes for involving local communities, communities of interest and others when preparing resource management plans and IFM plans, including their involvement when there is a risk of wildfire.
- Indicators should be included in all IFM plans to reflect site-specific realities and results.
- Plans should provide for a system to enable monitoring of important parameters and the adaptation of plans in light of evidence and changing circumstances.

4.15. WORKING WITH INDIGENOUS PEOPLES AND OTHER LOCAL KNOWLEDGE HOLDERS

Effective fire management can benefit from interculturality and dialogue between scientific and traditional knowledge systems. Fire knowledge encompasses people's understanding of the role of fire and its effects on economic, social, cultural and ecological processes and their interactions, as well as of management techniques and practices designed to achieve specific objectives and goals.

In many places, Indigenous Peoples and other local knowledge holders hold valuable and site-specific knowledge on beneficial fire-related practices that can contribute to better fire management outcomes. Their active engagement is crucial, not only to prevent wildfires and to promptly implement initial attack during ignition events but also to restore areas devastated by severe fire. Indigenous Peoples and other local knowledge holders often have good capacity and skills for on-site monitoring, understanding fire behaviour and its ecological effects, and using planned fire to manage fuels and create fuelbreaks. They should be informed about, consulted on and included in all five stages of IFM (i.e. review and analysis, risk reduction, readiness, response and recovery), as per the UN Declaration on the Rights of Indigenous Peoples and the right to free, prior and informed consent.

Strategic actions for increased inclusion of Indigenous Peoples and other local knowledge holders may include the following:

- Policies, programmes, research and contemporary fire management should be designed and implemented in collaboration with Indigenous Peoples and other local knowledge holders.
- Safeguards and free, prior and informed consent protocols related to IFM to protect and respect Indigenous Peoples and local communities should be established and applied.
- Benefit-sharing mechanisms linked to fire knowledge, practices, tools and technologies should be created in collaborative processes with Indigenous Peoples and other local knowledge holders.
- Adaptive measures should be supported (with resources and assistance) to better enable Indigenous Peoples, other local knowledge holders and rural smallholders to reduce the risk of wildfires and recover from them.
- Indigenous and local firefighters and community and volunteer fire brigades should be involved in fire management in their territories or surroundings and provided with safety equipment, supplies and training.

4.16. EQUITY IN INTEGRATED FIRE MANAGEMENT

Here, "equity" is understood as the process of treating people with fairness and justice. It should be pursued in all aspects of IFM programmes.

Gender-related dimensions are increasingly being discussed in the context of IFM, and important initiatives are being developed to raise public awareness of these. Integrated fire management programmes should consider the potential of people with disabilities and people subject to discrimination in various forms to contribute.

It is essential to recognize women's capacities and abilities to implement IFM-related activities and to acknowledge that their efforts, perceptions, needs and understandings are essential for effective IFM programmes. It is also important to identify and address the various difficulties and challenges women face at work, such as discrimination, harassment, salary inequality, unequal opportunities and heavy workloads (e.g. when combining professional careers with unpaid domestic labour and family care).

Integrated fire management should be conducted within a gender approach to guarantee inclusive, just and beneficial results to those involved (both directly and indirectly). Without the support and engagement of both women and men (young and old), all of whom have important roles that may be unique and do not always overlap, IFM processes will be incomplete and compromised, making the achievement of fire management goals more difficult.

Encouraging the full diversity of people to take part in IFM, regardless of gender, social status and personal constraints will increase the availability of fire-related knowledge and the management options available and help achieve and scale up best practices. For a true transformation, however, gender approaches need to be applied permanently and at multiple scales.

Strategic actions for gender equity in IFM may include the following:

- Fire-related policies and institutions should ensure that all fire professionals, regardless of sex, gender identity, ethnicity, culture, religion, race, disability or origin, are treated with respect and dignity and have fair, safe, bias-free and equitable working conditions.
- All IFM activities should be based on gender-inclusive approaches, considering cultural diversity.
- Roles, responsibilities and rights should be defined and disaggregated by gender, whenever appropriate.
- Integrated fire management programmes, initiatives and projects should establish gender-responsive objectives, activities and indicators.
- Anonymous reporting channels should be created to address cases of abuse, harassment or discrimination without exposing victims or leaving them vulnerable.
- Gender-disaggregated research should be conducted to collect information from different perspectives related to fire management and to inform improvements to working conditions.

4.17. MONITORING AND ASSESSMENT

The effective monitoring and assessment of an IFM programme can reduce the occurrence of damaging wildfires and the cost of suppression and ensure that the IFM programme is both effective and efficient.

Strategic actions for monitoring and assessment may include the following:

- A comprehensive plan for monitoring and assessing all aspects of an IFM programme should be developed and implemented.
- The safety of the IFM programme should be monitored, including analysis of near-miss incidents and accident reports and a review of lessons learned.
- Information and data from the IFM programme should be used to measure the effectiveness of wildfire prevention efforts.
- The ecological effects of fire and of suppression methods should be subject to a monitoring programme developed in cooperation with universities, other research organizations and local communities.
- A programme and framework should be implemented to incorporate lessons learned from monitoring and assessment of the IFM programme to ensure it is based on continuous learning with the aim of increasing efficiency and effectiveness.

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Conclusion

The IFM Voluntary Guidelines provide a framework for implementing an IFM approach, with five stages: 1) review and analysis; 2) risk reduction; 3) readiness; 4) response; and 5) recovery. The principles and strategic actions in this document are global in scope and are relevant to all elements of civil society and the private sector; FAO Members, as well as non-member countries; policy-level and other senior managers of subregional, regional and global governmental and non-governmental organizations; owners and managers – including women, youth, Indigenous Peoples and other local knowledge holders – of forests, rangelands, savannahs, grasslands and other ecosystems; all stakeholders concerned with protecting lives, human health, property and resources from the effects of damaging wildfires; and all stakeholders concerned with the use of fire to maintain ecosystems, cultures and socioeconomic benefits. Others – such as insurance companies, advocacy groups and specialists in communications, disaster management and public relations – may also find the principles and strategic actions herein useful.

It is anticipated that this document will be used for improving governance, education, guidance, benchmarking, cooperation and advocacy on all aspects of IFM. Its various features provide contexts for economic, social, cultural, environmental and political discussions at the subnational, national, regional and international levels. The principles and strategic actions can also serve as a checklist for strengthening policies, legal and regulatory frameworks, plans and procedures on IFM and, where these do not exist, they can provide a useful basis for developing them.

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Appendix 1: Conventions, agreements and declarations

Below is a select list of international conventions, agreements and declarations related to integrated fire management.

Conventions

- United Nations Framework Convention on Climate Change (UNFCCC);
- United Nations Convention to Combat Desertification;
- Convention on Biological Diversity;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- Convention on the Protection and Use of Transboundary Watercourses and International Lakes
- Convention on Long Range Transboundary Air Pollution (LRTAP)
- Ramsar Convention on Wetlands
- Other applicable rules of international law, including the respective obligations of governments pursuant to international agreements to which they are party.

United Nations declarations and statements

- 2030 Agenda on Sustainable Development adopted by all UN Members in 2015 created 17 world Sustainable Development Goals.
- UN Strategic Plan for Forests 2030 with six Global Forest Goals and 26 associated targets was forged at a special session of the UN Forum on Forests (UNFF) and subsequently adopted by the UN General Assembly in 2017.
- Glasgow Leaders' Declaration on Forests and Land Use signed by 141 countries at UNFCCC COP26 in 2021 committed to halt and reverse forest loss and land degradation by 2030, while delivering sustainable development and promoting an inclusive rural transformation.
- UN Decade on Ecosystem Restoration (2021–2030) aims to halt the degradation of ecosystems, and restore them to achieve global goals.
- The UNDRR resolution from the UN General Assembly in 2023 noted

the initiative of FAO and UNEP, in close cooperation with UNDRR to develop and implement a Global Fire Management Hub to reduce the increasingly worrying impacts of wildfires, in consultation with, and building on Members' expertise, existing intergovernmental processes and expert networks.

- UNFF19 in 2024 agreed to strive to adopt an integrated approach to wildland fire management, including early warning systems, to prevent, manage and address the negative impacts of extreme wildfires and related disasters, while recognizing ecological benefits of fire, through policy interventions and actions, harnessing science and technology, and enhanced international and regional cooperation, as appropriate, and in this regard noting the Landscape Fire Governance Framework presented at the eighth International Wildland Fire Conference held in Porto, Portugal in May 2023.

Appendix 2: Incident Command System

This appendix is a condensed and modified version of Paper 3, The Incident Management System, adopted by the International Wildland Fire Summit (Sydney, Australia, 2005). [24] This is based on the experience of incident management current at the time of publication. The variation, use, and application of incident management has evolved significantly and continues to evolve, including countries choosing to continue with their existing approach.[25]

The complexity of incident management, coupled with the growing need for multiagency involvement at incidents, has increased the need for a standard, interagency incident management system, not only within countries/states, but increasingly internationally. It is becoming ever more important to base international agreements on a common incident management system.

The Incident Command System (ICS) is a jurisdictional context approach that will need to be adapted to suit a particular country's existing political, administrative or cultural systems, customs and values. Where the primary purpose is to enhance emergency management and operations within a country, such adaptations are not only beneficial but may be essential to the adoption of the system. Given that ICS is a proven model in many countries, and given that training materials are freely available, there is considerable benefit to be gained by its adoption.

The ICS framework is an effective forum in which interagency emergency management issues can be addressed. By establishing a unified command of the respective agency/organizational representatives at a single interagency incident command location, the following advantages are achieved:

- One set of objectives is developed for the entire incident.
- A collective approach is taken to developing strategies to achieve incident objectives.
- Information flow and coordination are improved between all jurisdictions and agencies involved in the incident.
- All agencies with responsibility for the incident understand each other's priorities and restrictions.
- No agency's authority or legal requirements are compromised or neglected.
- Each agency is fully aware of the plan, actions and constraints of other agencies.
- The combined effects of all agencies are optimized as they perform their respective assignments under a single incident action plan.

- Duplication of effort is reduced or eliminated, thus reducing costs and the chance of frustration and conflict.

The ICS structure is based on the following principles:

- Common terminology: ICS terminology is standard and is consistent among all agencies involved.
- Modular organization: ICS structure can be scaled up to multiple layers that are implemented to meet the complexity and extent of the incident.
- Integrated communications: ICS requires a common communications plan, standard operating procedures, clear text, common frequencies and common terminology.
- Consolidated incident action plans: action plans describe response goals, operational objectives and support activities.
- Manageable span of control: a "manageable span" is defined as the number of individuals or functions that one person can manage effectively. In ICS, the span of control for any person falls within a range of three to seven resources, with five being the optimum.
- Designated incident facilities: these have clearly defined functions to assist in the effective management of the incident.
- Comprehensive resource management: the total resource is managed across all organizations deployed at an incident, including the maximizing of personnel safety.

The ICS incident organization structure is built around four major components:

- control – management of the incident;
- planning – collection and analysis of incident information and planning of response activities;
- operations – direction of resources in combating the incident; and
- logistics – provision of facilities, services and materials required to combat the incident.

These four components are the foundation upon which the ICS organization is built. They apply during a routine emergency, when preparing for a major event, or when managing a response to a major disaster. The ICS structure can be expanded or contracted to manage any type and size of incident.

Conclusions

Safety, effectiveness and efficiency are achievable when a seamless integration of agencies is enabled for a local-level incident as well as for international deployment to assist a country in need. A globally implemented standardized, on-scene operational management such as ICS will improve firefighter safety, efficiency and effectiveness in management response. ICS provides the model for command, control and coordination of an emergency response. It is a means of coordinating the efforts of agencies as they work towards the common goal of stabilizing an incident and protecting life, property and the environment. It also reduces the risk of agency overlap and potential confusion at an emergency owing to poor understanding and inadequate coordination.

It is critical that a common global incident management system is adopted, enabling any assistance to function quickly and effectively. ICS is a tool that can help achieve that goal.

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Glossary

Many of the terms are from FAO[26] and the GFMC,[27] with some additions or modifications to the original definitions in the 2006 edition, *Fire management: voluntary guidelines. Principles and strategic actions*.[1] FAO has also a team of fire specialists who interacted with external specialists to develop the glossary.

Community-based fire management (CBFiM)
Fire management approach based on the inclusion of local communities in the proper application of fire, fire prevention, and in preparedness and suppression of wildfires. CBFiM approaches can play a significant role in fire management, especially in most parts of the world where human-based ignitions are the primary source of wildfires that affect livelihood, health and security of people. The activities and knowledge that communities generally practise and apply are primarily those associated with prevention. They include planning and supervision of activities, joint action for prescribed fire and fire monitoring and response, applying sanctions, and providing support to individuals to enhance their fire management tasks.

Fire danger
A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control and fire impact – often expressed as an index.

Fire danger rating
A component of a fire management system that integrates the effects of selected fire danger factors into one or more qualitative or numerical indices of current protection needs.

Fire-dependent ecosystems
Fire is essential in maintaining predominant ecosystem composition, structure, function and extent. If fire is removed, or if a fire regime is altered beyond its historical range of variability, the ecosystem changes to something else;

dependent species and their habitats decline or disappear. Vegetation is fire-prone and highly flammable. Ecosystem structure and plant architecture facilitate fire spread. Boundaries between fire-dependent and fire-independent ecosystems are largely determined by the relative continuity of burnable fuels or probability of fire-enabling climatic conditions.

Fire hazard
(1) A fuel complex, defined by volume, type, condition, arrangement and location, which determines the degree both of ease of ignition and of fire suppression difficulty; (2) a measure of that part of the fire danger contributed by the fuels available for burning. Fire hazard is worked out from their relative amount, type and condition, particularly their moisture content.[1]

Fire-independent ecosystems
Fires characteristically would not occur because of a lack of fuel or ignition sources. Fire regimes can be altered by a change in fuels (e.g. invasive species) or ecologically inappropriate human-caused ignitions.[1]

Fire management
All activities required for the protection of burnable forest and other vegetation values from fire, and the use of fire to meet land management goals and objectives. It involves the strategic integration of such factors as knowledge of fire regimes, probable fire effects, values at risk, level of forest protection required, cost of fire-related activities, and prescribed fire technology into multiple-use planning, decision-making and day-to-day activities to accomplish stated resource management objectives.[1]

Fire management plan
(1) A statement, for a specific area, of fire policy and prescribed action; (2) the systematic, technological and administrative management process of determining the organization, facilities, resources and procedures required to protect people, property and forest areas from fire and to use fire to accomplish forest management and other land-use objectives (see fire prevention plan or fire campaign, pre-suppression planning, pre-attack plan, fire suppression plan, end-of-season appraisal).[1]

Fire prevention
All measures in fire management, fuel management, forest management, forest utilization and concerning the land users and the general public, including law enforcement, that may result in the prevention of outbreak of fires or the reduction of fire severity and spread.[1]

Fire protection
All actions taken to limit the adverse environmental, social, political, cultural and economic effects of fire.[1]

Fire regime
The patterns of fire occurrence, size and severity – and sometimes vegetation and fire effects as well – in a given area or ecosystem. It integrates various fire characteristics. A natural fire regime is the total pattern of fires over time that is characteristic of a natural region or ecosystem. The classification of fire regimes includes variations in ignition, fire intensity and behaviour, typical fire size, fire return intervals and ecological effects.[1]

Fire season
(1) Period(s) of the year during which fires are likely to occur and affect resources sufficiently to warrant organized fire management activities; (2) a legally enacted time during which burning activities are regulated by state or local authority. Many countries now experience significant wildfires during all months of the year and have transitioned to the term "fire year" (modified from the first edition).[1]

Fire-sensitive ecosystems
Ecosystem structure and composition tend to inhibit ignition and fire spread. The majority of species generally lack adaptations to respond positively to fire. Fire can influence ecosystem structure, relative abundance of species and/or limit ecosystem extent, or may occur naturally very infrequently or during extreme climatic events. Fire may create habitats for key species by creating gaps, regeneration niches or by initiating or affecting succession. If fires are too frequent or too large, they can be damaging and cause ecosystem shifts to more fire-prone vegetation. Some fire-sensitive ecosystems are also known as fire-influenced, particularly those adjacent to fire-dependent ecosystems.[1]

Fire suppression
All activities concerned with controlling and extinguishing a fire following its detection (synonyms: fire control, firefighting).[1]

Fuel
All combustible organic material in forests and other vegetation types, including agricultural biomass such as grass, branches and wood, infrastructure in rural or urban areas, which create heat during the combustion process.[1]

Fuel management
Act or practice of controlling flammability and reducing resistance to control of fuels through mechanical, chemical, biological or manual means, or by fire, in support of land management objectives.[1]

Fuel reduction
Manipulation, including combustion, or removal of fuels to reduce the

likelihood of ignition, potential fire intensity and/or to lessen potential damage and resistance to control.[1]

Incident Command System (ICS)
A standardized, on-scene operational management concept specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Integrated fire management (IFM)
The integration of fire management techniques and approaches with the ecological and socioeconomic roles of fire, where science, societies, Indigenous Peoples, traditional and local communities, and fire management technologies are considered at multiple levels. It is a holistic, participatory, adaptive and comprehensive approach that addresses fire and its interaction with biological, environmental, cultural, social, economic and political systems and dynamics. Its concepts should be upscaled and applied to all ecosystems and countries.[2]

Landscape fire
Cultural and ecological land-use fires, prescribed management fires and wildfires burning in live and dead vegetation of natural, cultural and urban-industrial landscapes (developed by FAO and the GFMC).

Planned fire
This term is synonymous with prescribed fire and has the same definition. A planned fire is a management-ignited fire or a wildfire that burns within prescription, meaning that the fire is confined to a predetermined area and produces the fire behaviour and characteristics required to attain planned fire treatment and/or resource management objectives. The act or procedure of setting a prescribed fire is called prescribed burning (see prescribed burning, prescribed fire).

Prescribed burning
Controlled application of fire to vegetation in either their natural or modified state, under specified environmental conditions, which allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to attain planned resource management objectives (see prescribed fire). Note: this term has replaced the earlier term "controlled burning".

Prescribed fire
A management-ignited fire or a wildfire that burns within prescription, meaning

that the fire is confined to a predetermined area and produces the fire behaviour and fire characteristics required to attain planned fire treatment or resource management objectives or both. The act or procedure of setting a prescribed fire is called prescribed burning (see prescribed burning, planned fire).

Prescription
Written statement defining the objectives to be attained as well as the conditions of temperature, humidity, wind direction and speed, fuel moisture and soil moisture under which a fire will be allowed to burn. A prescription is generally expressed as acceptable ranges of the prescription elements and the limit of the geographic area to be covered.

Rehabilitation
The activities necessary to repair damage or disturbance caused by wildfire or the wildfire suppression activity (see restoration).

Restoration
Restoration of biophysical capacity of ecosystems to previous (desired) conditions. Restoration includes rehabilitation measures after fire or prescribed burning where certain fire effects are desired (see rehabilitation).

Risk
(1) The probability of fire initiation due to the presence and activity of a causative agent; (2) a causative agent.

Smoke management
The application of knowledge of fire behaviour and meteorological processes to minimize air-quality degradation during prescribed fires.

Wildfire
Any unplanned and uncontrolled vegetation fire that, regardless of ignition source, may negatively affect social, economic, or environmental values, and require suppression response or other action according to agency policy (modified from the first edition).[1]

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Further reading

The following bibliography does not intend to provide an all-embracing list of sources. Rather it aims to facilitate the in-depth search for literature on fire ecology, history, management and related fields such as atmospheric chemistry, climatology and remote sensing. The list includes major monographs and sourcebooks with references to a broad secondary literature, as well as internet portals that facilitate literature search. Also included is a list of references introducing the topics of global fire, climate change, and learning to live with fire.

From 2023, the online repository of the Global Fire Monitoring Center (GFMC) is being integrated into the Global Fire Management Hub. At the time of this update of the *Integrated Fire Management Voluntary Guidelines – Principles and strategic actions* (2024), reference is given to selected GFMC posts and other online resources.

Online Library of the Wildland Fire Research Institute

Previously known as Fire Research Institute, its name was changed in 2022 to Wildland Fire Research Institute (WFRI). It was founded in 1983 to benefit research in fire across the globe. WFRI is a not-for-profit wildland fire library with a database of approximately 150 000 citations on all the topics related to landscape fires:

- https://wifri.org/

The Tall Timbers E.V. Komarek Fire Ecology Database

The donation of personal research collections from E. V. Komarek and Herbert L. Stoddard, who were two of the key founders of Tall Timbers, was the original impetus for the Tall Timbers Board of Trustees to mandate creation of a computerized bibliographic database. Since its inception in 1987, the database has been continually expanded under the direction of the Tall Timbers library. Although international in scope, the database emphasizes the southeastern United States of America (USA), the USA, and North America. Historical and current works are included. Currently, there are over 30 000 citations in the database.

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MONOGRAPHS AND TEXTBOOKS

The following monographs and textbooks include numerous references to journal publications including grey literature. Some are available as open-source digital versions and are marked with a URL for online access through the digital version of the FAO Fire Management Voluntary Guidelines. Others are available in libraries or on demand, as print and digital versions by the publishing houses.

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Community-based, cultural and Indigenous fire management

The GFMC provides a portal to access resources of community-based, cultural, Indigenous and integrated fire management.

- https://gfmc.online/manag/cbifm.html

Among a range of literature including media and grey-literature reports, the following themes are addressed in the portal:

- Community-based fire management (CBFiM) basics
- Village defense
- Training
- Gender
- Children
- Indigenous Peoples' communities
- Religious communities
- Migrants and refugees
- Protected areas
- Country reports/activities

The following three volumes include a broad range of information and sources on CBFiM and cultural / Indigenous Peoples' fire use:

FAO. 2002. *Communities in Flames: Proceedings of an International Conference on Community Involvement in Fire Management.* P. Moore, D. Ganz, L.

Cheng Tan, T. Enters & P.B. Durst, eds. Bangkok, FAO Regional Office for Asia and the Pacific.

Myers, R.L. 2006. *Living with fire: sustaining ecosystems and livelihoods through integrated fire management.* Tallahassee, USA, The Nature Conservancy, Global Fire Initiative.

Pasiecznik, N. & Goldammer, J.G., eds. 2022. Towards fire-smart landscapes. *Tropical Forest Issues 61.* Ede, the Netherlands, Tropenbos International.

Vázquez-Varela, C., Martínez-Navarro, J.-M. & Abad-González, L. 2022. Traditional fire knowledge: A thematic synthesis approach. *Fire*, 5(2): 47. https://doi.org/10.3390/fire5020047

Fire management

This list of classical and recently published textbooks and monographs provide comprehensive secondary literature:

Arnaldos Viger, J., Navalon Nonel, X. & Pastor Ferrer, E. 2004. *Manual de ingeniería básica para la prevención y extinción de incendios forestales.* Madrid, Mundi-Prensa.

Belcher, C.M., ed. 2013. *Fire phenomena and the Earth system. An interdisciplinary guide to fire science.* Chichester, UK, Wiley Blackwell.

Bradstock, R.A., Gill, A.M. & Williams, R.J., eds. 2012. *Fire regimes, biodiversity and ecosystems in a changing world.* Collingwood, Australia, CSIRO Publishing.

Brown, A.A. & Davis, K.P. 1973. *Forest fire: Control and use.* New York, USA, McGraw Hill.

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Chuvieco, E. & Martín, M.P. 2004. *Nuevas tecnologías para la estimación del riesgo de incendios forestales.* Madrid, Consejo Superior de Investigaciones Científicas.

Cochrane, M.A. 2009. *Tropical fire ecology: Climate change, land use, and ecosystems dynamics.* Chichester, UK, Springer Praxis.

Cowling, R., ed. 1992. *The ecology of Fynbos: Nutrients, fire and diversity.* Oxford, UK, Oxford University Press.

DeBano, L.F., Neary, D.G. & Ffolliott, P.F. 1998. *Fire's effects on ecosystems.* New York, USA, John Wiley & Sons.

Goldammer, J.G., ed. 2013. *Prescribed burning in Russia and neighbouring temperate-boreal Eurasia. A publication of the Global Fire Monitoring Center (GFMC).* Remagen-Oberwinter, Germany, Kessel Publishing House.

Heikkilä, T.V., Grönqvist, R. & Jurvélius, M. 1993. *Handbook on forest fire*

control: A guide for trainers. Forestry Training Programme (FTP) Publication 21. Helsinki, Finland, National Board of Education, Government of Finland.

Heikkilä, T., Grönqvist, R., Jurvélius, M. & Goldammer, J.G. 2013. *Handbook on forest fire control.* Pushkino, Russian Federation, Helsinki, Finland & Freiburg, Germany.

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Organisation for Economic Co-operation and Development (OECD). 2023. *Taming fires in the context of climate change.* Paris, OECD Publishing. https://www.oecd-ilibrary.org/environment/taming-wildfires-in-the-context-of-climate-change_dd00c367-en

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Porrero, M. 2001. *Incendios forestales: Investigación de causas.* Madrid, Mundi-Prensa.

Pyne, S.J., Andrews, P.J. & Laven, R.D. 1996. *Introduction to wildland fire. Second edition.* New York, USA & Chichester, UK, John Wiley & Sons.

Rego, F.C., Morgan, P., Fernandes, P. & Hoffman, C. 2021. *Fire science: From chemistry to landscape management.* Cham, Switzerland, Springer Nature.

Rodríguez-Trejo, D.A. 1996. *Incendios forestales.* Mexico City, Mundi-Prensa.

Teie, C.W. 1997. *Fire officer's handbook on wildland firefighting.* Rescue, USA, Deer Valley Press.

Teie, C.W. 2003. *Fire manager's handbook on veld and forest fires: Strategy, tactics and safety. South African edition.* Pool, C.F. ed. Pretoria, South Africa, Southern African Institute of Forestry.

Vélez Muñoz, R., ed. 2000. *La defensa contra incendios forestales: Fundamentos y experiencias.* Madrid, McGraw-Hill.

Vélez Muñoz, R. & Vega, J.A., eds. 2000. *Actas de la reunión sobre quemas prescritas.* Madrid, Sociedad Española de Ciencias Forestales.

Fire management guidelines

The GFMC provides a portal to fire management guidelines from throughout the world. The web post is continuously updated:

https://gfmc.online/literature/fire-management.html

Among others, the portal includes:

FAO. 2002. *Guidelines on fire management in temperate and boreal forests.*

Forest Protection Working Papers, Working Paper FP/1/E. Rome.

Goh, K.T., Schwela, D.H., Goldammer, J.G. & Simpson, O. 1999. *Health guidelines for vegetation fire events. Background papers*. Published on behalf of UNEP, WHO & WMO. Singapore, Institute of Environmental Epidemiology, Ministry of the Environment & Namic Printers.

Goldammer, J.G. & de Ronde, C., eds. 2004. *Wildland fire management handbook for sub-Sahara Africa*. Freiburg, Germany & Cape Town, South Africa, Global Fire Monitoring Center.

International Tropical Timber Organization (ITTO). 1997. *ITTO guidelines on fire management in tropical forests*. ITTO Policy Development Series No. 6. Yokohama, Japan.

Landscape Fire Governance Framework. 2023. *Guiding Principles for Adjusting Strategies, Policies, and Management, to Global Change.* https://assets.website-files.com/625eec974c68b24b4ed75bb5/64df3d8c07e6565f7631b8c9_Framework%20AGIF%20-%20ENG%20V2.pdf

Schwela, D.H., Goldammer, J.G., Morawska, L.H. & Simpson, O. 1999. *Health guidelines for vegetation fire events. Guideline document.* Published on behalf of UNEP, WHO & WMO. Singapore, Institute of Environmental Epidemiology, Ministry of the Environment & Double Six Press.

Schwela, D.H., Morawska, L.H. & bin Jafar, A.B. 1999. *Health guidelines for vegetation fire events. Teachers' guide.* Published on behalf of UNEP, WHO & WMO. Singapore, Institute of Environmental Epidemiology, Ministry of the Environment & Double Six Press. U.S. fire information systems and software products: www.fire.org/

Gender, equity, diversity, inclusion and justice

The GFMC provides a dedicated portal on the role of women in fire management. The web post is continuously updated with enlarged view and materials on diversity, inclusion and justice:

- https://gfmc.online/manag/gender_main.html

Among numerous scientific and media reports, the following key publications are accessible online:

Espada, A.L.V. & Oliveira, M.S. 2022. *Diversidade, inclusão e equidade de gênero no programa manejo florestal e prevenção de fogo no Brasil: Estudo técnico.* First edition. Brasília, USFS-USAID.

FAO. 2011. *Women in agriculture: Closing the gender gap for development.* Rome.

FAO. 2022. *FAO's work on gender in forestry*. Rome.

Global fire, climate change and learning to live with fire

Archibald, S., Lehmann, C.E.R., Belcher, C.M., Bond, W.J, Bradstock, R.A, Daniau, A.L., Dexter, K.G, et al. 2018. Biological and geophysical feedbacks with fire in the Earth system. *Environmental Research Letters,* 13(3). https://dx.doi.org/10.1088/1748-9326/aa9ead

Birot, Y. 2009. *Living with wildfires: what science can tell us.* EFI Discussion Paper 15. Joensuu, Finland, European Forest Institute.

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Bowman, D.M.J.S., Balch, J., Artaxo, P., Bond, W.J., Cochrane, M.A., D'Antonio, C.M., DeFries, R., et al. 2011. The human dimension of fire regimes on Earth. *Journal of Biogeogaphy,* 38: 2223–2236. https://doi.org/10.1111/j.1365-2699.2011.02595.x

Bowman, D.M.J.S., Williamson, G.J., Abatzoglou, J.T., Kolden, C.A., Cochrane, M.A. & Smith, A.M.S. 2017. Human exposure and sensitivity to globally extreme wildfire events. *Nature Ecology & Evolution,* 1: 0058. https://doi.org/10.1038/s41559-016-0058

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de Groot, W.J., Wotton, B.M. & Flannigan, M.D. 2015. Wildland Fire Danger Rating and Early Warning Systems. In D. Paton, S. McCaffrey, F. Tedim & P. Buergelt, eds. *Wildfire Hazards, Risks and Disasters,* pp. 207–228. New York, Elsevier.

Doerr, S.H. & Santín, C. 2016. Global trends in wildfire and its impacts: perceptions versus realities in a changing world. *Philosophical Transactions of the Royal Society B*, 371(1696). http://doi.org/10.1098/rstb.2015.0345

FAO. 2006. *Fire management: review of international cooperation.* Fire Management Working Paper 18. Rome.

FAO. 2011. *Community-Based Fire Management, a review.* Forestry Paper 166. Rome.

Flannigan, M.D., Krawchuk, M.A., de Groot, W.J., Wotton, B.M. & Gowman, L.M. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire,* 18(5), 483–507. https://doi.org/10.1071/WF08187

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He, T., Lamont, B.B. & Pausas, J.G. 2019. Fire as a key driver of Earth's biodiversity. *Biological Reviews,* 94(6): 1983–2010. https://doi.org/10.1111/brv.12544

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McCaffrey, S. 2015. Community Wildfire Preparedness: a Global State-of-the-Knowledge Summary of Social Science Research. *Current Forestry Reports,* 1: 81–90. https://doi.org/10.1007/s40725-015-0015-7

McFarlane, B.L., McGee, T.K. & Faulkner, H. 2011. Complexity of homeowner wildfire risk mitigation: An integration of hazard theories. *International Journal of Wildland Fire*, 20: 921–931.

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Smith, A., Kolden, C., Paveglio, T., Cochrane, M., Bowman, D., Moritz, M., Kliskey, A., et al. 2016. The science of firescapes: achieving fire-resilient communities. *BioScience,* 66(2): 130–146. https://doi.org/10.1093/biosci/biv182

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Williams, J. 2013. Exploring the onset of high-impact mega-fires through a forest land management prism. *Forest Ecology and Management*, 294: 4–10. https://doi.org/10.1016/j.foreco.2012.06.030

THEMATIC JOURNALS

International Journal of Wildland Fire (IJWF): IJWF publishes new and significant papers that advance basic and applied research concerning wildland fire. The journal welcomes papers aimed at understanding the basic principles of fire as a process; its interactions with the weather and climate; its impacts on ecology, hydrology, geomorphology, landscape carbon dynamics, the atmosphere, and society; modelling fire and its effects; and presenting information on how to effectively and efficiently manage fire. Manuscripts from physical, biological and social sciences will be considered. The journal has an international perspective, since wildland fire plays a major social, economic and ecological role in many regions of the world and strongly interacts with global climate change:

- https://www.publish.csiro.au/wf

Fire: ***Fire*** is an international, peer-reviewed, open access journal covering the science, policy and technology of fires and how they interact with communities and the environment, published monthly online by MDPI. Launched in November 2017, *Fire* was considered the journal following-up the UNECE/FAO International Forest Fire News (IFFN). The Global Wildland Fire Network is affiliated with ***Fire***:

- https://www.mdpi.com/journal/fire

UNECE/FAO International Forest Fire News (IFFN): IFFN was a key activity of the FAO/UNECE Team of Specialists on Forest Fire and the Global Fire Monitoring Center (GFMC) and constituted the first international newsletter/journal covering forest fires and other vegetation fires at global level. In 1989–2014 IFFN was printed and published on behalf of UNECE Timber Committee and the FAO European Forestry Commission. In 2017, the concept of IFFN was integrated into the journal *Fire*. All 45 volumes, which contain scientific and technical reports on forest fires and other landscape fires around the world, are archived and available digitally:

- https://gfmc.online/iffn/iffn.html

WEB PORTALS ON INTERNATIONAL COOPERATION IN FIRE MANAGEMENT

General – Online repository of the Global Wildland Fire Monitoring Center (GFMC):

- https://www.gfmc.online/

Landscape fire science and management glossaries

- https://gfmc.online/literature/glossary.html

Fire management guidelines

- https://gfmc.online/literature/fire-management.html

Online publications, libraries and bibliographies

- https://gfmc.online/literature/landscapefire.html

Global Wildland Fire Network

- https://gfmc.online/GlobalNetworks/globalNet.html

United Nations role in international cooperation in fire management

- https://gfmc.online/programmes/un/un.html

International agreements for assistance in fire emergencies

- https://gfmc.online/emergency/int_agree.html

Portal to global landscape fire information systems (near real-time) and recent actively burning landscape fires by various open access and commercial providers

- https://gfmc.online/current/globalfire-2.html

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Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-138916-4 ISSN 2664-1062

9 789251 389164

CD1090EN/1/06.24